April 24 1903

*Next Meeting April 24, 1903. Subject: Tendencies of Central Station Development.*

Entered as matter of the second class at the New York, N. Y. Post Office, November 16th, 1892.

VOLUME XX.
NUMBER 3. } MARCH, 1903. Annual Subscription $6.00
Single Copies - .50

# TRANSACTIONS

OF THE

# AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

## CONTENTS.

Library Dinner, Monday, February 9, 1903 ..... 265
Associates Elected ..... 297
Announcement of Annual Convention at Niagara Falls, June 29, July 3 ..... 304
Railway Train Lighting. Introduction by President Scott ..... 305
An Electric Car Lighting System. By W. L. Bliss ..... 309
Axle Lighting. By Elmer A. Sperry ..... 331
An Axle Light System of Train Lighting. By Arthur J. Farnsworth ..... 339
Some of the Problems of Electric Train Lighting. By Geo. D. Shepardson ..... 349
Discussion at New York ..... 355
Discussion on Railway Train Lighting at Pittsburg, March 12, 1903 ..... 369
Discussion on Railway Train Lighting at Schenectady, March 7, 1903 ..... 373
Communication After Adjournment of Schenectady Meeting. By R. Nell Williams ..... 375
Discussion on Telegraphy at Denver, February 26, 1903 ..... 376
Discussion on Railway Train Lighting at St. Louis, February 27, 1903 ..... 376
Discussion on Railway Train Lighting at the University of Illinois, March 7, 1903 ..... 377
Discussion on Railway Train Lighting at the Western University of Pennsylvania, March 12, 1903 ..... 377
Discussion on Railway Train Lighting at the Ohio State University, March 12, 1903 ..... 377
Discussion on Railway Train Lighting at the University of Wisconsin, March 12, 1903 ..... 377
Discussion on Railway Train Lighting at the University of Missouri, March 14, 1903 ..... 377
Discussion on Railway Train Lighting at Boston, March 26, 1903 ..... 378
The Arcophone. By R. A. L. Snyder. A paper read at the 4th Meeting of the Pittsburg Branch, February 5, 1903 ..... 379
Accessions to the Library ..... 383
Advertisements ..... 394

PUBLISHED MONTHLY (EXCEPTING JULY AND AUGUST) BY THE INSTITUTE, UNDER THE SUPERVISION OF THE EDITING COMMITTEE.

[COPYRIGHT BY AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.]

RALPH W. POPE, *Secretary*,
95 LIBERTY STREET, NEW YORK CITY.
Telephone, 2190 Cortlandt.

# TRANSACTIONS

OF THE

# AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

Vol. XX. MARCH, 1903. No. 3.

## OFFICERS AND BOARD OF DIRECTORS, 1902-1903.

**PRESIDENT:**

CHARLES F. SCOTT.
Term expires 1903.

**JUNIOR PAST-PRESIDENTS:**

CARL HERING. CHARLES P. STEINMETZ.

**VICE-PRESIDENTS:**

| Terms expire 1903. | Terms expire 1904. |
|---|---|
| DR. MICHAEL I. PUPIN. | BION J. ARNOLD. |
| DR. SAMUEL SHELDON. | C. O. MAILLOUX. |
| GEORGE F. SEVER. | DR. SCHUYLER S. WHEELER. |

**MANAGERS:**

| Terms expire 1903. | Terms expire 1904. | Terms expire 1905. |
|---|---|---|
| JOHN J. CARTY. | JOHN W. LIEB, JR. | GANO S. DUNN. |
| W. S. BARSTOW. | PROF. W. E. GOLDSBOROUGH | E. H. MULLIN. |
| RALPH D. MERSHON. | COL. SAMUEL REBER. | CHARLES A. TERRY. |
| CALVIN W. RICE. | R. T. E. LOZIER. | TOWNSEND WOLCOTT. |

**TREASURER:** Terms expire 1903.

GEORGE A. HAMILTON,
463 West Street, New York.

**SECRETARY:**

RALPH W. POPE,
95 Liberty St., New York.

**PAST-PRESIDENTS.**

DR. NORVIN GREEN, 1884-5-6.
FRANKLIN L. POPE, 1886-7.
T. COMMERFORD MARTIN, 1887-8.
EDWARD WESTON, 1888-9.
PROF. ELIHU THOMSON, 1889-90.
PROF. W. A. ANTHONY, 1890-91.
ALEX. GRAHAM BELL, 1891-2.
FRANK J. SPRAGUE, 1892-3.
DR. EDWIN J. HOUSTON, 1893-4-5.
DR. LOUIS DUNCAN, 1895-6-7.
DR. FRANCIS B. CROCKER, 1897-8.
DR. A. E. KENNELLY, 1898-1900.
CARL HERING, 1900-1901.
CHARLES P. STEINMETZ, 1901-2.

# AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

## COMMITTEES AND LOCAL HONORARY SECRETARIES.

### STANDING COMMITTEES.

**Executive Committee.**
CHARLES F. SCOTT, Ch'm.
JOHN J. CARTY.
GANO S. DUNN.
GEO. A. HAMILTON.
CALVIN W. RICE.
RALPH W. POPE.

**Committee on Finance.**
JOHN J. CARTY, Chairman.
W. S. BARSTOW.
CALVIN W. RICE.

**Committee on Papers.**
DR. S. SHELDON, Chairman.
BION J. ARNOLD.
T. C. MARTIN.
CHAS. P. STEINMETZ.
H. G. STOTT.

**Board of Examiners.**
WM. MAVER, Jr., Chairman.
F. W. ROLLER.
HENRY A. LARDNER.
L. B. STILLWELL.
TOWNSEND WOLCOTT.

**Library Committee.**
WM. D. WEAVER, Chairman.
GANO S. DUNN.
WILLIAM J. JENKS.
CHARLES E. KNOX.
LEONARD WALDO.

**Editing Committee.**
GANO S. DUNN, Chairman.
EDWARD CALDWELL.
HENRY A. LARDNER.

### SPECIAL COMMITTEES.

**Local Organizations.**
CALVIN W. RICE, Chairman
GANO S. DUNN.
P. G. GOSSLER.
W. E. GOLDSBOROUGH.
SAMUEL SHELDON.

**Membership Committee.**
W. S. BARSTOW, Chairman.
J. J. CARTY.
W. E. GOLDSBOROUGH.
SAMUEL REBER.
W. D. WEAVER.

**Building.**
CALVIN W. RICE, Ch'm.
WM. D. WEAVER.
C. O. MAILLOUX.
DR. S. S. WHEELER.

**Reception.**
T. C. MARTIN, Chairman.
WILLIAM J. HAMMER.
E. H. MULLIN.
B. GHERARDI, JR.
W. S. BARSTOW.
W. HAND BROWNE.
ARTHUR WILLIAMS.
F. C. BATES.
CALVERT TOWNLEY.

**Collection of Data on Transmission.**
RALPH D. MERSHON, Chairman.
F. O. BLACKWELL.
C. C. CHESNEY.
P. M. LINCOLN.
C. L. CORY.

**National Electric Code.**
A. E. KENNELLY, Chairman.
L. A. FERGUSON.
P. G. GOSSLER.
F. A. C. PERRINE.
C. P. STEINMETZ.
ARTHUR WILLIAMS.
C. J. H. WOODBURY.

**Theses.**
GEO. F. SEVER, Chairman.
W. S. BARSTOW.
F. W. ROLLER.

**Standardization.**
PROF. H. J. RYAN, Chairman.
H. W. BUCK.
JOHN F. KELLY.
RALPH D. MERSHON.
J. S. PECK.
PROF. E. B. ROSA.
CHAS. P. STEINMETZ.

### Universal Exposition, St. Louis, 1904.

**Committee on Plan and Scope.**
PROF. W. E. GOLDSBOROUGH, Chairman.
DR. A. E. KENNELLY. T. C. MARTIN.
PROF. GEO. F. SEVER. PROF. ELIHU THOMSON.

### Local Honorary Secretaries:

RICHARD H. PIERCE,
1409 Manhattan Building, Chicago.

JAMES S. FITZMAURICE,
210 George St., Sydney, N. S. W.

GEORGE P. LOW,
320 California St., San Francisco, Cal.

EDWARD P. BURCH,
1210 Guaranty Building,
Minneapolis, Minn.

H. F. PARSHALL,
Salisbury House, London Wall, E.C., London, Eng.

PROF. ROBERT B. OWENS,
McGill University, Montreal, P. Q.

CLARE F. BEAMES,
City of Mexico.

W. G. T. GOODMAN,
Dunedin, New Zealand.

## LIBRARY DINNER
OF THE
## AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

HELD AT SHERRY'S, NEW YORK, MONDAY, FEBRUARY 9, 1903.

At the conclusion of the service of the dinner, President Charles F. Scott said:

It is my pleasant duty to extend to you, ladies and gentlemen, Members and guests, a hearty welcome to our Annual Dinner.

Within the past year the INSTITUTE has been privileged to do honor to two men of world-wide fame. The dinner of last year was in honor of Signor Marconi. It followed shortly after the flashing of a single letter across the wireless ocean. The three dot message was so meagre that it was almost in doubt, but it made Marconi the hero of the hour. A second memorable event was the reception given to Lord Kelvin, whose name is indelibly connected with the first signalling across the ocean. Lord Kelvin told us the interesting story of the early days of the Atlantic cable. He told of the messages which demonstrated the possibilities which lay within the cable and of the accidents which followed and of the difficulties which were overcome after years of patient labor. The cable was not ready for service until eight or ten years after the first message.

It is notable that before our annual dinner of this year every letter of the alphabet has passed across the wireless sea and a lengthy message of gratulation has likewise flashed from President Roosevelt to King Edward of England.

But things move faster in these days than in the olden time. Progress and activity mark every department of life. Scientific discovery, invention, engineering development—all these underlie the awakening of recent years. To such an audience as this I

need not dwell upon the importance of electricity in the new era nor recite the many ways in which it has led to the revolution of old methods and the evolution of new ones. But I do emphasize the magnitude of the work which devolves upon the youngest of the professions and the need of developing effective men and efficient methods. With few exceptions, the electrical enterprises of the present day, in which $4,000,000,000 of capital are invested, have grown up within the past fifteen or twenty years. Not only that, but the men upon whom this work has depended for its inception, its development and its operation have likewise been developed during the same time. They have worked without precedents. There has been no lamp of engineering experience to guide. Nor have electrical matters stood still. One set of problems is scarcely met before new requirements arise.

Note the evolution in electrical transportation in New York City. Ten years ago horse cars were being replaced by cable cars. Scarcely had their places in turn been taken by the electric surface cars before the equipment of the elevated railway with its extensive and exacting service was undertaken. Before the Manhattan trains were in operation an underground system was planned with heavier trains and higher speed, and long before the Rapid Transit is started, the Pennsylvania Tunnel is undertaken for trains operating under steam railway conditions.

Responsibilities of increasing magnitude confront the electrical engineer. What provisions are there for making his work more certain and more efficient? What means are there for selecting out of the vast and varied sum total of achievement, that which is most worthy to become standard practice? What are the forces which tend to coöperation and advancement among electrical workers and in electrical work?

In reply to these questions I desire to present the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS as a definite positive force for the advancement of the electrical engineering profession and its work. The INSTITUTE cannot take as its type the learned societies of the old school. A new era has come. Modern science and engineering belong to a new order of things. The electrical engineering profession is unique. Electricity enters into so many departments of our modern civilization that its function is difficult to describe. If I were called upon to state the effect of electricity in briefest terms I would reply, *Electricity increases efficiency*. By its use the world's work may be done more quickly and at less cost. The telephone is an instantaneous

messenger, it doubles the work a man can do. The railway motor, the motor in the mine, the crane motor, the motor in the machine shop, bring results more quickly and more cheaply. Electrochemical processes produce cheaper products. The electric light adds to the hours of efficient activity. Electricity has given to the whole world a new method of doing things—of doing them more efficiently in time and in cost. The work of the electrical engineer is not separate and apart, it is interwoven with every branch of engineering, with every industry, with commerce and in a score of ways with the conveniences and necessities of every-day life. The history of the past few years and the tendencies of the present promise an expanding future. Activity is the characteristic of America. It is the keynote of American electrical engineering. The national organization which represents the electrical profession must be an active organization, it must be a broad organization, it must have an ever-expanding ideal. It must take a definite grasp upon present conditions and it must be a positive force in electrical engineering advancement. Its mission is not restricted to the welfare of the electrical engineer alone, but through him and through his work it comes in touch with our modern life in as many points as electricity itself. He was reputed a benefactor of the race who made two blades of grass grow where one had grown before. How much more a benefactor is he who controls the subtle agent that can double the effectiveness of effort in a thousand ways.

The INSTITUTE must be in touch with many men. To one class of our membership are admitted only those who have attained a high standard in the electrical profession. To the other belongs the larger body of electrical workers. The ideal of the one is dignity; the ideal of the other is usefulness.

There are those who question whether the extension of our membership may not compromise our dignity and lower our standards. But I question whether we are truly representative of the Electrical Engineers of America and whether we can exert our proper influence upon electrical progress while there are outside our ranks thousands of electrical workers—not only those advanced in the profession and those prominent in pursuits closely associated with electrical applications, but young men of promise—the engineers of the future. We have failed to catch the spirit of the times and the keynote of electrical progress if we do not realize that we must expand and broaden and progress as well as maintain high standards of excellence. Full member-

ship should be exclusive; associate membership should be inclusive.

The benefits which come from activity and association are being secured through the many Local Branches which have been formed during the past half year. In a dozen or twenty cities and colleges, among INSTITUTE members and among students there are local meetings usually following shortly after the New York meetings at which the original papers with their discussions are reviewed and again discussed by members and students. There is scarcely any other means which can conduce more to the effectiveness of our INSTITUTE in directly strengthening and developing the electrical workers of America than a system of local meetings which brings together men in electrical work and puts the students in educational institutions in touch with present problems.

In its influence upon electrical engineering progress the INSTITUTE is doing a good work. Its Transactions are a continuous panorama of electrical engineering progress. The work of its Standardization Committee and of its National Electric Code Committee has been an influencing factor in establishing definite and uniform practice; its Transmission Committee for securing and publishing extended data upon high tension transmission is now actively at work. A new Committee has just been established for the collection and publication of general electrical engineering data. This will be an efficient medium for the publication of useful and up-to-date data which may be furnished by engineers or by manufacturing companies.

We are looking forward to the time when we may have a building which will be suited to the dignity and the demands of our Society. We have been holding our meetings in the assembly rooms of a sister society. On many occasions those standing almost equaled the number of those seated. I am among those who constitute, I believe, a large and growing number among American engineers, whose ideal is a magnificent engineering building giving adequate accommodations to many societies, where each may have the individual facilities which will enable it to carry on its own particular work most advantageously, and it will have those common facilities, such as a large assembly hall and reception room, and a general library, which will be of the greatest common advantage and benefit. The value and influence of such a building is not merely in the convenience of the building itself, even a greater benefit is its influence as a

definite material representative of the general engineering profession and the coöperation between engineering societies and engineers.

President Pritchett of the Massachusetts Institute said at the Stevens Institute inauguration last week that "Isolation indicates a low state of civilization." Let us be civilized! Let us coöperate!

This modern world of ours depends most vitally for its efficient operation upon the engineer whose work enters so fundamentally and so completely into everything which differentiates our material conditions from those of the savage who preceded us. May it not be that our present prosperity is not merely a crest on the recurring cycle of financial ups and downs, but a normal condition in a new era of wealth production, which has been brought about through the thought and effort of the engineer!

It is of inestimable consequence that every means should be afforded for increasing the effectiveness and the efficiency of the engineering profession. As electricity has been a unifying element in modern affairs, making it possible to operate street cars and passenger trains, elevators and printing presses and machine shops, to light the lamps in street and office and home, to illuminate the advertising sign, to heat the curling iron and to cook the luscious steak—all from one system, from one power house, from one dynamo; so, likewise, may not the electrical engineer be a unifying agent among the engineering professions? Let the spirit of the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS be—not isolation—but coöperation.

We are here to-night for the special purpose of directing our attention to one of the fundamental departments of the INSTITUTE. We are to celebrate the founding of its Library.

How fitting it is that the national engineering society which without reflection upon its sister societies may claim to represent most closely the modern idea in industrial and engineering activity should have as the foundation and the nucleus of its electrical library, a library for research and for reference, such a collection as the noted Latimer Clark Library which was secured and presented through the appreciation and generosity of our own member, Dr. Schuyler Skaats Wheeler.

What is the estimate which those who have been prominently connected with industrial and engineering work place upon the value of a library? An English engineer in referring to the American iron and steel industry makes this statement: "The

most remarkable industrial development in the history of iron making is mainly the result of two factors, the popularization of practical science by the American scientific journals and the courage and inventive genius of the American iron masters."

We are proud to do honor to the men who have been prominent in this great development. Our INSTITUTE has taken part with other societies in the founding of the Medal in honor of the venerable John Fritz. We are closely related to another man of iron and steel. He has been successful, he has accumulated wealth, but he has also followed the new Gospel of Wealth.

In what way, let us ask, has this man, whose ability has enabled him to accumulate one of the largest fortunes that a man has ever possessed and who has given the best years of his life to a study of problems of industry, of government and of progress, and the needs of his fellow-men—by what channels, by what means has this man found that he can most efficiently employ his wealth for great and noble ends? You all know the answer. The Carnegie Steel Company is not so widely known as the Carnegie Library. And, how fitting it is that the means for cataloging and otherwise making our library useful should have been contributed by the man so highly appreciative of libraries, who has done so much to extend their usefulness and their popularity—Andrew Carnegie.

Our members have not been in the receiving mood alone. A score or two of them, as well as attorneys and companies and societies have been generous, not only in contributing collections of past works, but in several cases in providing endowments for continued additions; and more than one has provided in his will that his technical library shall pass to the INSTITUTE. Such a foundation, accompanied by such appreciation and such interest is well worthy to be celebrated by the INSTITUTE in its annual dinner, with guests so illustrious in the library and the literary world, as those who honor us by their presence to-night.

TOASTMASTER MARTIN:—You have been informed, ladies and gentlemen, by no less an authority than our esteemed President, Mr. Scott, that this is our second annual dinner. I have noticed it as a peculiarity of Presidents that they date everything from the time at which they took office. I did it some fifteen years ago myself (laughter) and have since then wondered what other presidents could find to do. This is not exactly our second annual dinner. There are others of us who have attended earlier feasts, but I think we can say that it is the second occa-

sion upon which we have mustered in such large numbers and with such enthusiasm as characterizes our gathering to-night.

As Mr. Scott has reminded you, one year ago we had the honor and pleasure of entertaining Mr. Marconi, who had just taught the ether to spell the one letter "S." Since that time the ether has succeeded in mastering every letter of the alphabet. When I had the opportunity, a week or so ago, of asking Mr. Marconi to be with us this evening, he expressed his regret that he could not join us, and he said that his time and his hands were full of creating an "Ether Library."

It is due to the New York Edison Company to inform you that circuits and current which furnish us special illumination this evening are supplied through their generosity and courtesy. It is also due to our friend, Mr. Russell Spalding, of the Elblight Company, of America, to state that the beautiful festoons which you see around the room are supplied by Mr. Spalding and the company. The INSTITUTE desires through me to thank the New York Edison Company and its officers and Mr. Spalding and the Elblight Company for the service they have done us to-night.

As I came down Pittsburg Row to-night—I mean Fifth Avenue—I had a dim sort of speculation whether my esteemed friend on the right would really allow me to begin my duties, and would not take from me the pleasure of beginning at the beginning of the programme. These new Pittsburg men are very worthily proud of each other, and it has seemed to me a singular felicity that we should have one Scott introducing a brother Scot to-night, both of them hailing from that nation which has been justly characterized as irrepressible (laughter.) Our President is himself an example of that band of brilliant young engineers who, directed by the finest executive and financial skill this world has ever seen, have made the name of our greatest industrial center, Pittsburg, known throughout the civilized world. So that while the iron and steel industry may justly claim its Carnegie and its Schwab, we, too, will boast our Westinghouse and our Scott. Also our Calvin Rice, and so on, through all the degrees and Lamme-nations.

As Mr. Scott has said to-night, we electrical engineers, we younger men, came late into the world. We found everything pre-empted; the others had been here before us—the earth and the waters under the earth, the coal deposits and the iron mines had already been taken up, and there was nothing left for us but

the vacuum and the ether. We are to-day creating tangible properties out of these intangible elements. But it stands to reason that for the great majority of the members of this INSTITUTE the opportunities are somewhat scarce and scant, the emoluments cannot be large and the salaries will be small—for a few of us more rewards will come through inventions—but to most of us the opportunity to do that which is in our hearts for the INSTITUTE will always be more or less lacking. Once in a while we shall find our " angel " and shall then be able to contribute to the work which the INSTITUTE is doing. I have even ventured to think for myself that had I the good fortune to meet our friend Mr. Carnegie earlier in life it might have been a good deal better for both of us.

There are two good reasons why Mr. Carnegie, our guest of honor to-night, should be with us. One is that he is *one of us*, and I do not think he will chide me if I venture to remind him that some of the first good, honest money that he earned in this world was made in the service of electricity at the key and the sounder, with our good friend, Thomas Alva Edison. And that is why to-night we hang upon our walls our " 73." Mr. Carnegie understands that a good deal better than a good many others of you—

MR. CARNEGIE (sotto voce):—Yes, I do.

MR. MARTIN:—A second good reason why Mr. Carnegie should be with us to-night is summed up in the magic word " library."

> " The play's the thing,
> Wherein I'll catch the conscience of the King."

said Hamlet, and when I said " library," I ventured to hope and believe I might get Mr. Carnegie to be with us to-night, because he lets no guilty library escape. Our work appeals to Mr. Carnegie who, I venture to assure you, is a discriminating giver and has to be extremely careful as to what he does. Only the other day in this city he awarded to a small boy a gold medal for fishing a man out of the Hudson River. The police of this city tell me that since that time the waters of the North River and the waters of the East River and the waters of the Lower Bay have simply been aswarm with small boys trying to earn another gold medal.

I do not know how Mr. Carnegie regards it, but we are the good little boy who has his first medal, I believe, in the ranks of the engineering societies; and I do not believe that anything would

give Mr. Carnegie a greater pleasure than to see our sister societies do as we have done and join hands with us so that our libraries might be of benefit to the world. I was one of a party at the trial trip of a motor—an electric car—in a village up the Sound a week or two ago, and after the trial trip of the motor we were entertained by a well-known millionaire at his house in company with several others. We were having a good time, and as our legs were stretched under his mahogony he looked pleasantly down the long board and said, "Now, you fellows, I want you all to have a good time, because I don't think many of you will ever be here again." I do not know that it will ever be my honor and privilege and good fortune to introduce Mr. Carnegie to another audience, and you will therefore forgive me if I have made the most of the present opportunity. Gentlemen, our friend, our benefactor, Andrew Carnegie, Rector of St. Andrew's University.

(Three cheers for Andrew Carnegie. The cheers were lustily given.)

MR. CARNEGIE:—Mr. Toastmaster: I suppose he takes precedence even of the President, and I address him first, because he is an editor in addition to being a toastmaster and they rule the world nowadays—and you, my fellow Scot, Mr. President, Ladies and Gentlemen, with especial emphasis, superior to that upon either editor or President, upon the ladies. The engineers of Ameica, set many good examples; particularly the electrical engineers. Permit me to congratulate the INSTITUTE upon having ladies at your banquet—they give an air of distinction and refinement which nothing else can produce.

You say truly, Mr. Irrepressible Toastmaster (laughter), that I have a right to be here among the electrical engineers. Before the electrical engineer was, Mr. Edison, Mr. Barclay and myself, we messenger boys—were. There was no engineering electricity in those days, but I have very delightful reminiscences of those days, and chew the cud over them many and many a time. The greatest change that ever came over me was when I passed from the dirty cellar where I was firing and running the steam engine (and many a time was afraid it would explode, because I did not know whether I was firing right or not, as I was not an engineer), and translated to a telegraph office, where they had clean writing paper and pencils and windows—that, ladies and gentlemen, was my first glimpse of paradise on earth in my early career in making a livelihood. The telegraph office was to me

a paradise, and I began surreptitiously to practise on the instruments in the morning before the operators came. The line was not completed to New Orleans when I first began to practise on the key, but it was completed before I became an operator and received the tremendous salary of twenty-five dollars a month.

The line was completed during the time I was practising, and I called up New Orleans in the morning—the boys got Louisville to connect—that I might say N. O. G. M., New Orleans, Good Morning, and the answer came back "Good Morning, Pittsburg." I said to myself, this is what Swedenborg, that wild Swedish seer, said about heaven, "space is annihilated." So when I see Mr. Edison sitting there and Mr. Barclay, and think of us three; with the privilege of mature years I turn to you and say, "Boys, you are modern, you're a new generation; we are your pioneers, your predecessors, but looking at you and knowing what you have done, no father was ever prouder of his boys than Edison, Barclay and myself are of this generation which has succeeded us."

I have been looking you all over—well, with an occasional glance at the ladies, for which I hope I may be excused. Gentlemen, America has been first in electricity. As Mr. Martin has truly said, you came late upon the scene. To Britain, the other half of our race, we are indebted for all the great inventions upon which depend the material progress of the world. Our advance is focused upon the steam engine of Watt, with one arm spreading over the sea in the boat of Symington, seven years before Fulton, and another arm spreading it over the land in the locomotive of Stephenson. That is the triad upon which the material progress of the world rests, and that was before we of America were. I may remark that all three of these gentlemen were Scotch. I called Mr. Martin irrepressible, and he is a sample of the American. The American does not get left; he does not take "no" for an answer; he knows how to court a woman—"no" doesn't mean anything; and he knows how to court fortune—"no" doesn't mean anything; and he knows how to get a man to a dinner after he has declined three times. The man who wins is the fellow that says to woman, or to fortune, or to the gods themselves, who refuse, "Don't believe you; you don't mean it." The American says "I am going to get there anyhow," and that is what the American does. You take Edison and Stanley and Thomson and you take Scott and Martin and other great lights I see around me—there were no

corresponding men in the old branch of the race, it takes the electrical atmosphere of America to produce such electrical forces as these men, such hustlers. One man has just said to me, " Mr. Carnegie, that man Martin is what you say—but he came from Jamaica." That puzzled me—Jamaica, an Englishman. Well, there is no saying what you can do with a Scotchman or an Englishman if you catch him young enough. Mr. Martin said to me, " Mr. Carnegie, I feel a bond of sympathy with you "—this is Martin's style—" there's a bond between you and me, my mother was a Scotchwoman, of Edinboro." That accounts for Martin.

The toastmaster mentioned St. Andrew's University—there was another Scotchman greatly honored there last October by being made a doctor—Graham Bell—another inventor; so that even in electricity do not forget that there is a little Northern half of an island in the North Sea that is not to be left out of account very often when anything good or great is to be done.

The President struck the keynote of the success of the American. I have often taken occasion to say—and I have known both lands well—the American men, this body of electrical engineers, for instance, are the most coöperative men, I believe, that exist to-day. You remember what Emerson said about the Briton—every Briton was a little island by himself, not communicable with others; they are exceedingly distinctive; they do not coöperate well—they want to go each their own way; but there is this about the American which is different from most other men—he is fair-minded; I don't think the American wishes to override; he is not implacable; is not prone to irritate or to make enemies. I think there is a harmonizing feature about him, which counts for everything in the progress of any great movement, political, social or scientific. And it is institutions like this of the Electrical Engineers which do so much; you cannot over-estimate the influence such organizations exert. You hear a man spoken of as Mr. Pope, your Secretary, was spoken of; I noticed the outburst of applause; that appreciation; that feeling that his fellows, his associates, his friends appreciate him—that man would rather have the appreciation of a few of his friends who know how to judge him than he would have the plaudits of a million who knew not his services. The test of greatness is not the popularity of a man, is not how widely he is spoken of; the true test of greatness, as it is of goodness and personal virtues—is what his colleagues think of him, how they rate him. Take

any of these young men—Edison, Sheldon, Thomson, Fritz, Stanley, or even Martin, though an editor—what do his colleagues think of him? Their approval is the crown of victory that will bring out all the man's reserved force. That is wanting in any nation which does not know how to assimilate, how to combine the social with the scientific. When men who work with you at the bench or at the desk or at the machine become your best friends—and their appreciation, the highest mark that you can win depends upon this—the enterprise in which you are engaged has behind it such a force as nothing else can give it in this world.

President Humphreys, of Stevens' Institute, made a remark to me the other day. He said, "Mr. Carnegie, I read your Rectorial address in which you compared Britain to the other nations of the world. I think you very correctly describe the conditions. I have an American friend who has lived in Britain and has a large business there, and he says that Britain will never equal America, because in America the man who does the work gets recognition, status, social position and everything follows him in America if a man performs service." In Britain it is not so.

I go further than that—our Republican institutions are to be credited with much of the vigor, the ability and the success with which we are going forward to the material supremacy of the earth.

We are all here together in this room. There is not a hair's breadth of difference between any of us. There is not a right or a privilege that one man has that is not every man's right. We are not asking who your forefathers were, or what they did, or what your rank or position of wealth is; we are asking what you do, how you behave yourself, and let all the other nations go into manufacturing, or science, or research, or anything you please—I tell you this nation has a tremendous advantage in that, that we stand, not for the position of this or that family, but for the work of the individual man. That is the card that wins, and that is the reason I back America against all the other nations in the world, because she is a Republic where any man's privilege is every man's right.

TOASTMASTER MARTIN:—Ladies and Gentlemen: When the menu and order of exercises was being made up, my friend on the right said, "Well, by the merest chance Mr. Carnegie may refer to Scotland, and so I would be glad if you would spell the Skaats out in full in my name." As Mr. Carnegie says, it takes a great many nationalities to create an American.

I attach a great deal of interest to and sometimes look with a great deal of pride and perhaps a little pathos on an old and somewhat yellow paper which my good friend Dr. Wheeler and I drew up together eighteen years ago, proposing that the INSTITUTE should have a library, and in our document we mentioned the Latimer Clark Collection as the element and the foundation with which we would like to begin. At that time we were both poor and struggling young men of genius (laughter) and we did not exactly know where the money was to come from, but we had faith in our profession and perhaps a good deal more in ourselves, and so we put that document together and signed it and it is in the archives of the INSTITUTE to-day. I would not have mentioned this, but for the fact that Dr. Wheeler's name is on it. Shortly after that episode our good friend Dr. Wheeler distinguished himself by inventing that which I think is perhaps the most typically American invention of the last century—a machine known as the fan motor, which will distribute more hot air in large quantities in a given time than any other known machine in the world. I was encouraged by the success on my friend's part and was glad to see him move on to higher and larger enterprises. I was glad to encourage all my friends to go into it as a good thing, something which might even prove to be a gold mine. Dr. Wheeler's success is known to you all, for he is one of those who, as Mr. Carnegie has said, has carried our name as engineers, inventors and designers of machinery around this great globe. In doing that, I venture to hope and believe Dr. Wheeler has achieved a competency; at least he gave us a faint indication of that fact when he purchased the Latimer Clark collection for us. I shall never forget the thrill of satisfaction I had when, on going to the telephone one evening, I heard his voice at the other end of the line, and he said: "Martin, I see the Latimer Clark collection is for sale at last. Do you remember what we did some years ago? I wonder if we can get it for the INSTITUTE?" I think it was within the brief space of two weeks that we had the much-coveted Latimer Clark collection. (Applause.) Gentlemen, the Latimer Clark collection is now yours, thanks to the generosity and public spirit, and the altogether altruistic and disinterested action of our Dr. Wheeler. Now, we have had gifts from men outside of the INSTITUTE and are glad of them and proud of them, but we have to do something for ourselves. Dr. Wheeler and I, since preparing that document, have seen the investment in electrical apparatus rise from

less than $1,000,000,000 to $4,000,000,000, and we venture to hope that at least a portion of that wealth will be turned into the treasury of the INSTITUTE. Only yesterday, in the Sunday paper, I read a cable despatch which stated that this wonderful radiating material, known as radium, was being sold in London at the rate of $900,000 a pound, chiefly to American electricians, and I could not help wondering how many of them were standing in line. I know I was not—I was too busy buying coal—but if we have men in our ranks who can thus afford to take up radium at that rate, surely we may venture to hope and believe that they will also purchase for us a little of that intellectual radium, that infinite, brain power of the intellect represented and preserved in the library.

No pleasure that I enjoy to-night in discharging the lugubrious duties of toastmaster will afford me a keener and deeper thrill than now to present to you and to ask you to receive him with cheers three times three, our fellow-member, Dr. Schuyler Skaats Wheeler, the founder of the INSTITUTE Library. (Three cheers were given for Dr. Wheeler.)

DR. WHEELER:—Mr. President, Ladies and Gentlemen: I shall not say very much about the Clark collection, because I do not know much about it; and if I had realized at the time of its purchase that it would result in my having to stand up here to-night and do an after-dinner stunt, I think I would have kept clear of it altogether! I did examine the exteriors of numerous enormous boxes at the appraiser's office and watched the Collector of the Port while he ripped open their hermetically sealed linings and read all the books, most of which are in Latin. As books that are over twenty years old are entitled to free entry, he was about to say, "I do not see anything here to collect on," when he came across a couple of tons of the current issues of the electrical papers, the *Review*, of London, and the *World*, of New York. He then said that I must pay duty on these. He asked me how $125 would strike me, and I said it did not strike me at all, but as I was tired of waiting I would pay it. Then I went away. The next day I received a bill for $250, and went down and made some remarks about it. Then I was told the whole thing had been passed and now no power on earth could change it! That is about the way the books got into the city.

When I first began to take notice of things electrical, I thought I would like to know something about the telegraph and so I turned to my encyclopedia and read up on the subject, and there

I found the telegraph described as a series of towers spreading across the country several miles apart, depending on whether the country was hilly or not, each tower carrying a swinging arm. (This is a long story, but I have the point in view.) The operator in one tower would watch the arms in the next tower and when its arms were moved he would move the arms in his tower accordingly, and in that way signals were transmitted across the country by the process now called "wig-wagging." I made up my mind it was time to purchase a new encyclopedia and did so, and then the publishers of the encyclopedia asked me to re-write the article on Telegraphy. I had to make it fit the same space that the old article had occupied so that they would not have to change the page numbers. That was more difficult than describing the telegraph. This was the method of signalling used in England in 1816 and in France, at any rate according to Dumas in his Count of Monte Cristo. Shortly after that time a scientific man named Francis Ronalds invented an electric telegraph. His telegraph consisted of 400 feet of wire laid underground, with a clock at each end, but in place of the hour marks on the dials of the clocks were the letters of the alphabet. He would send a spark over the wire, the operator at the other end would see what letter the hour hand pointed to, and in that way they started out on a system of electric telegraphing. The Government at that time in England was relying on the wig-wag telegraph for signalling from London to the dockyard at Portsmouth. Ronalds was anxious to get the Admiralty to take up his new electric telegraph, and he made a great many efforts to get the authorities interested in it. Finally, they turned him down in the following rather remarkable message from Sir John Barrow, Secretary of the Admiralty:

"Mr. Barrow presents his compliments to Mr. Ronalds and acquaints him, in reference to his note of the 3d inst., that telegraphs of any kind are now wholly unnecessary and that no other than the one now in use will be adopted.

Admiralty Office, 5th August, 1816."

Francis Ronalds was a scientific man. He was director of the Kew Observatory, a man in delicate health, and also of a very sensitive disposition. This episode caused him to leave electricity entirely. He went to Italy and remained there for ten years and during that time he amused himself making a very fine collection of electrical books. He consulted the book dealers all over the world and got them to send him lists of what they had that was attractive and he prepared a very fine catalogue of all the elec-

trical books extant. He left this library to trustees to be presented to the British Institution of Electrical Engineers. A few years before he died he was made a Knight. Up to this time this was the finest electrical library there was, but unfortunately the trustees did not present it promptly to the Institution. They kept it about ten years and there was more or less haggling about it which gives the matter rather a bad taste, but finally the British Institution received it.

Then Latimer Clark, who had been collecting books, kept on adding more and his correspondence and records give every indication that he was very anxious to make a finer collection than Ronalds. All through his catalogues and correspondence are notes everywhere such as "This book is not in Ronalds'," etc. Evidently the desire to surpass Ronalds's collection was one of his incentives in making his own a fine collection. This in a way is the history of the gathering together of these, our books. A few years ago the executors of Mr. Clark wanted to dispose of the books, and some friends of mine, wishing to enlist the support of a well-known patron of libraries, thought they would write him a letter calling his attention to the fact that this library could be had. They then conceived a second thought, which was that it would be very nice to have a newspaper clipping to enclose with their letter. They did not have such a clipping, so they deliberately set about manufacturing one by writing up an article, pretty nearly a column long, describing the library, which they published in their paper. This was to be cut out and sent to this prominent patron of libraries, but in the natural course of events a regular issue of the paper containing the article fell under my eye and I called up the proper source of information and found who had the books. I cabled for them and got them.

I think the matter of appreciating these books is a very hard subject. They treat of all sorts of things. It is impossible to read them all—I know I cannot; and in fact, from reliable information, I understand that the INSTITUTE itself has employed an expert guide and interpreter to tell it what the books are. There are very many interesting things in the collection. Of course, there is the first book that was ever printed! And then there is the first book that was ever printed which mentions in any way electricity or magnetism, and then there is the first book that was ever printed in English, which mentions anything on the subject, and then there is the first book that was devoted entirely to electricity and magnetism, that is, was issued as a

separate treatise on the subject, all previous books having only incidentally mentioned it, and so on, through an innumerable list of books that have some special interest. Then there is the book which Galileo wrote containing sentiments which were not altogether approved of, and for which he afterwards did time.

I am very enthusiastic about having a good collection of electrical books in this city, and I am delighted to see that the subject received such warm support all around, that there are so many contributors and such extensive contributors, because there is no question that this city is destined to be the electrical business centre of the world, if it is not now.

TOASTMASTER MARTIN:—President Scott has received this dispatched from Cincinnati:

"The Cincinnati Branch assembles to-night fifty-five strong. It extends greeting to the parent society and its honored guest. Tell Andrew Carnegie we can use a library too."

MR. CARNEGIE:—Hand that over to Wheeler.

MR. MARTIN:—I like to witness the emulation or rivalry of great, generous souls. I did not suppose for a minute that either of them was through. Our last speaker in his remarks has touched on the scope and extent of our INSTITUTE Library, and it is really remarkable the manner in which it illustrates the sentiment which is attached to the next toast, namely, "The Unity of Science." An electrician never knows where to stop reading in order that he may add to his store of useful information. My good friend and old instructor in electricity, Mr. Thomas A. Edison, told me once how he began reading in the free library at Detroit, a mere bit of a boy, but still an omnivorous reader, and having no one to instruct him as to the pursuit of his studies he began at the bottom of the first stack, at the end of one shelf, and read straight through fifteen feet of it. He was about to begin on the second fifteen feet, when the librarian thought it was about time to investigate the proceedings of that extraordinary youth.

About a year or two ago I was again impressed with my good friend's, my hero's omnivorous appetite and thirst for knowledge, when being in his library I happened to say that I had never seen in print that I could remember the original statement of Joule of his famous law. The "Grand Old Man's" eye gleamed, and he pulled out a book and read to me there and then the identical passage about which I expressed a little curiosity.

I sometimes wonder what is going to happen to the publishers when this library furore gets through. An old friend of mine

whom Mr. Carnegie will remember, the late James D. Reid, once told me how, when building the telegraph line through to Pittsburg and finding that the circuit was leaking, he determined to insulate it and immediately proceeded to smear the whole wire with beeswax. He says that never since have the bees all down through the Alleghenies and the Valley of the Monongahela had such a boom time as they had that year. Our good friend, Mr. Carnegie, has been beeswaxing the publisher's circuits for a long time.

We have with us to-night to respond to this toast one who is not only distinguished as a publisher, and especially as a cataloger, but one whom we are glad to welcome again as one of ourselves and as an old Edison man, Mr. R. R. Bowker, of the *Publisher's Weekly*.

Mr. Bowker:—Mr. President, the Irrepressible, Ladies and Gentlemen: I am not quite sure of good standing in this goodly company, because I cannot claim, like Mr. Carnegie, Mr. Edison and others who have accomplished things, to be a reformed telegrapher. There used to be a book entitled, "Men Who Have Risen." I suppose the next generation will read that book as "Men Who Have Telegraphed." But I can bring one "character" to this occasion. In the antediluvian days of the New York Edison Company, when I did duty as its Executive, there was a public-spirited and private-spirited gentleman who had just finished his palace on Fifth Avenue but had not yet occupied it, when he received an electric light bill. He came in great excitement to the Edison offices and insisted on coming to headquarters with his light bill. He said that he had asked the architects about this bill for $346, and was told that they had been moving furniture, etc., on the elevator, but could not account for more than half of the bill. I asked our friend if no one had noticed a decimal point between the 3 and the 4, whereupon he paid his bill for $3.46 and went away to ask further questions from the architects. Afterwards I learned that in his judgment I was the only man in New York who knew anything about electricity—I suppose because I was the only man who had ever shown him how to reduce an electric light bill. But I come before you rather as a member of "the executive profession," who has had something to do with electricity in the course of a varied business career, to speak to you rather from the layman's than from the engineer's point of view.

So short a time ago, Mr. President, as when I was in college, our electrical equipment consisted chiefly of a galvanic battery,

warranted to kill fourteen freshmen in series—we never tried it to its full capacity—the Geissler tubes which Prof. Pupin later turned to so good purpose, and never returned, and an electro-magnet which under the inspiration of that same battery would grow a beard of a hundredweight of tenpenny nails in less than half a jiffy. That was a great outfit for those days, and the contrast with college equipment of to-day tells, in a sense, the story of electrical development. To think that one person within this generation—as has been my personal experience—should have handled, reverently, from the hands of the noble woman who dictated that inspiring message, the first telegraphic despatch with its wonderful prophecy, "What hath God wrought?" should have known the man commercially responsible, Cyrus W. Field, and the man electrically responsible, now Lord Kelvin, for the first Atlantic cable; should have received, at the Como exhibition commemorative of Volta, one of the first despatches without wire, and later have sent wireless messages from ship to shore; should have witnessed Elisha Gray's earliest showings of his form of telephone from room to room of a private residence; should have seen Prof. Pupin in his laboratory working out that wonderful tuning system, extending the range of the telephone, possibly across sea, for which tune the piper had to pay a quarter to a half million dollars; should have seen a great electrical system grow from nothing until it reached and outreached a million lamps' equivalent; should have known the first electric station in which Edison did his pioneer work and in which he discovered that inevitable element in every electrical enterprise, the electric "bug"; should have seen the generating unit grow from Edison's wonderful "steam Jumbo" of 150 horse-power to the 300 horse-power, the 600, the 1200, the 2500 horse-power unit, until now the unit of 5,000 horse-power, the size of the great turbines at Niagara Falls, is that which you see in many great electrical stations to-day—to think that all this which I have indicated has been accomplished within the compass of one short generation, that is an epitome in itself of the progress which this industry of ours has made—an art new-born, responding to a science new-born. For throughout all electrical progress, this creating of a new art, the important fact has been the mutual responsiveness of science and art, the flowering of science into art, and the response of art to science, step by step.

All the way along from the days when Lavoisier and Berzelius, at the beginning of the nineteenth century, gave to chemistry

reasonable names and its algebraic language, how wonderful has been the growth of every science until at last all of them seem to have culminated and concentered in our own. And all that progress has been a progress in and toward unity, a progress also at an accelerating speed, for it seems as though, as the last century put away its hundred volumes on the book-shelves of time-that century had told us more than all the centuries that had gone before, the latest generation more than all the generations that had gone before, the latest years more than all the years that had gone before. And now, progressing in and toward that unity, we face the questions which the nineteenth century has left for the twentieth century to solve.

With all its achievements, the nineteenth century has done the one great thing of putting question-marks for the twentieth century to answer, and it is that to which the twentieth century is now applying its talents. It seems as though Nature has no exceptions to her laws, as though every time she presented an exception it is only with the query into what greater law does this fit. Let me take one example which has already been touched upon to-night. Two or three years ago in London I remember being seated at a dinner given by Lord Kelvin, between himself and Becquerel, soon after the great French chemist had made the start in his contributions toward our knowledge of the extraordinary properties of uranium, and Lord Kelvin said that Becquerel's discovery of the radiant properties of that element seemed to be the first note of query that had been put against the conservation of energy since that great doctrine took its place in our scientific knowledge. To-day the real nature of the "Becquerel rays" is one of the chief questions put before us, and those Americans who are in line in London to secure their share of radium at $900,000 a pound, will be asking questions concerning that still more wonderful newly-discovered element as to what it really does, whether really and truly it is throwing out its atoms at a velocity equal to that of light so that in the year 2003 they would have melted a column of ice a quarter of a mile thick, the supposed limit of its ultimate energy, or whether it will be proven that its light or radiation is simply another phase of radiant energy. Of course it is radiant energy with which the electrician, above all, is dealing. When we glance along the sciences, there seems no longer any division line; the chemist and the physicist are one, the atom is itself perhaps only a mode of motion. And the *chef* who has supplied us this excellent dinner

would be without his calling were it not that somehow in this marvelous electrical organization the, human body, the nerves which translate the sensations of food apparently into electrical vibrations, send the telegraphic messages to the brain. The physician of to-day will tell you that his eye is fixed most keenly upon these new developments of radiant energy which have such marvelous relations to the human body, and it seems that we may be on the brink of a discovery that physical substances are known to us only through the messages of their vibrations, which have to be translated into terms very like electricity before we recognize them at all, so that all the problems of science find the path of unity a possible answer in terms of electricity.

It is interesting, Mr. President, that at last the INSTITUTE has recognized practically through the gift of those generous donors, Dr. Wheeler. Mr. Carnegie and others, the desirability of bringing together into one place all the knowledge that can be had in books as to what electricity means, because the knowledge of the past is the only safe ground for advance into the future. The generations past built cathedrals; the library is the cathedral of to-day. And no nobler cathedral could be made than one in which the representatives of the several engineering sciences should meet together with the equipment of a great library which would answer all the questions which could possibly be asked of the past. So not only the INSTITUTE, but the whole electrical profession, is to be congratulated that this INSTITUTE has arrived at the point where a great library is to be its next work, and I think every one should be stimulated to give of their own collections to make this collection adequate and approximately complete, and so far as possible, to concentrate all knowledge in this field.

To me one of the most beautiful symbols in the world exists in the old Mexican city of Vera Cruz, the City of the True Cross, where there were more churches than modern life had time to use. One of those old churches to-day represents what we have come to know as the library spirit—what we also know as the Carnegie spirit—for the lower part of it is used as the home of a public library, and its tower for a beacon which throws its light far out upon the sea. So, with the foundation of the library as a basis for the far-reaching beacon of electricity, how much will this INSTITUTE mean in the future! And let us hope that everything that it does will give to its members the inspiration of the widest thought of the man of science. May I read to you, in conclusion, a few lines of alliterative Saxon fashion, in which I try to suggest the range and the unity of his work:

THE MAN OF SCIENCE.

" He weaves the whole world one with weft of wire,
Till at one touch it throbs and thrills and thinks,
Then wins the wireless wave to hail and hark.
For him the lightning fills Aladdin's lamp
And fiercest force is free or fast at will.
One beam builds bridge across the boundless blu
And brings him secrets of the spectred stars.
Rev'rent he reads rude records of the race
And from faint footprints fashions the full frame.
Watching with wisdom's eye the witless worm,
He scorns not from the small to grasp the great
Seeing sure-eyed beyond the scope of sense
And tracing throughout all the timeless throught,
Strong-souled to serve, and by the service save—
Such, Science, is the seeker at thy shrine ! "

TOASTMASTER MARTIN:—In the creation of the INSTITUTE Library we are glad to secure expert advice of the highest order; and I think we can say we have that when we call upon our friend Dr. J. S. Billings, Director of the New York Public Library, to speak to the toast, " The Technical Library." I have much pleasure in introducing Dr. Billings to address himself to that subject.

DR. BILLINGS:—Mr. President, Mr. Toastmaster, Ladies and Gentlemen: In the early days of the exploitation of electric light systems in this country, an objection urged by the engineer of one company against the light of another company, was that the other company's light was surrounded by " so much non-luminous verbosity," a very serious objection. In the light which I am to turn on the subject of technical libraries, I am going to endeavor to avoid it by being very brief.

Technical libraries, that is to say, collections of technical books, are pretty old. I suppose the first ones were theological libraries; but technical libraries in the modern sense began with the patent systems, and the best general technical libraries in existence to-day are those connected with the Patent offices of various countries. The relations of technical libraries to great general libraries are of some interest. I have looked over the collection of technical books in the Library of the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, and find that it is very complete in the separate works relating to electricity alone, and its applications as it stands to-day. Much literature on this subject is contained in that of other departments, so that the investigator may wish to see the transactions, journals and reports of learned societies

that at the present time do not perhaps seem to have any connection with this work. These you are accumulating and you have been extremely fortunate in being able to get some of the great sets of such reports and journals. Now, these journals and transactions of the learned societies in London, Paris, Berlin, Vienna, etc., are in the New York Public Library, and as your library is not yet well known, there are more engineers who come to read these volumes in the New York Public Library than to read those in your library, and at first sight one might think it raised the question which it is said was raised after the discovery of the law of the conservation of energy—a statement of the mechanical equivalent of heat by the first engineers who went to the infernal regions and after looking around inquired if there was not a tremendous waste of energy there.

I think both libraries are necessary; the public library and the special library. The special technical library of the special society, if so managed as thoroughly to enlist the interest of the men who use it, will receive many things which would not ordinarily come to the public library. I found that to be the case with the medical library in Washington. This technical library is now the greatest and most complete medical library in the world, and this is due to the fact that it was kept separate from the Library of Congress. The doctors did not take any special interest in the books when they were in the general collection, did not feel bound to look after them or give service to them. There should be what has been talked about here to-night—coöperation between the two. It is not necessary both should have everything. For example, take the book referred to in the programme to-night, that of Albertus Magnus, printed in 1494. That is not primarily an electrical book and is of small importance in connection with electricity. It is in the New York Library for another and different reason. So it is with a number of other books which are in your library because there are two or three lines in them about electricity. There are some very old books that it is not worth while for both libraries to have. The first great encylcopedia, the very first, is in the New York Public Library, but it is not in the Institute Library, and it will be many years before it will be there, no matter what price you offer for it, and it is not worth while for you to get it.

The men who consult the books in the Astor Library want the collections of patents, books on physics, transactions of engineering societies, etc., to refer to. Most of them want the latest

periodicals. That is the demand you will have in your library—it is the latest periodical literature they want; the text books are of small interest for the engineer who is up-to-date in his work. He wants the very latest literature and that is what he goes to libraries for. There is plenty of room in New York for two of these collections; and in the case of patents it would be good for you to have collections of the electrical patents. I do not know anything that is needed by the engineers of New York in the way of literature to-day so much as a full collection of the German patent specifications. We have the English, French and American; the German specifications are not here. Should both the INSTITUTE and the Public Library endeavor to get them? I think not. The INSTITUTE may confine itself possibly to getting the specifications for the electrical patents, and yet there will be many specifications for other patents that your members will want to read, and it is hard to say what they will want to read. If they want anything that you have not secured for your library, the chances are that we shall have them at our library. So I think there is plenty of room for both; and abundant opportunity for putting energy into both.

Your library is in first class condition now; and I congratulate you heartily upon it and upon the way in which it has been taken up. I congratulate you upon another thing in connection with it, which perhaps you may not quite understand at present, but which you will understand in years to come, and which is more important than the books and that is that you have a man who is thoroughly intelligent, zealous, enthusiastic and persevering to look after your library, push it on and take care of it, look after its interests, in the person of the chairman of your Library Committee.

TOASTMASTER MARTIN:—I was glad indeed to hear the reference to the chairman of the Library Committee from one who is the best judge in this country of the value and quality of such work—I mean our good friend and fellow-member, Lieutenant Commander W. D. Weaver. I think it only fair to Mr. Weaver to say that the work which he does for the library is entirely a matter of self-sacrifice and labor of love.

I now have the pleasure of calling upon Mr. Theodore L. De Vinne, who will speak on the subject, "The Debt of Mechanics to Science."

MR. DE VINNE:—Mr. Toastmaster, Mr. President, Ladies and Gentlemen of the AMERICAN INSTITUTE OF ELECTRICAL ENGIN-

EERS: I feel as if I were somewhat out of place. If there is any one present who knows less about electricity than I do, his ignorance is deplorable. My business is that of recording and preserving the thoughts and experiments of other people, and not that of trying to record my own; and yet I cannot let the occasion pass by, as I am probably one of the oldest men in the room, without calling your attention to the work that has been done in the application of electricity in a relatively few years, in fact, less than an ordinary lifetime.

It was about sixty years ago, during my last term in school, that I attended the lectures on Natural Philosophy, and there I saw for the first time what we would now call a very crude electrical apparatus. I wondered at it, and so did my classmates—wondered at the incessant and apparently fruitless activity of the machine. One of the class asked the teacher if that electric power or force could not be turned to good account, and be applied to mechanics. The teacher shook his head and said no; that Prof. Page, the scientific expert at Washington, was then trying to utilize it, but so far with small success. The teacher said he had no doubt the time would come when it would prove a success, but at the present time we should regard the electrical machine, and in fact all exhibits of electrical apparatus shown in ordinary schools and colleges, as nothing more than scientific toys. This was in 1842. Fifty years after that I stood in the pit of the Niagara Falls Power Company and gazed with undisguised admiration and astonishment at the gigantic machines that were set up there. I was told it was proposed to send light, heat and power to the distant cities of Rochester and Buffalo. So they did. It is but two years ago that I was at the Pan-American Exposition, and there I saw by the simple operation of turning a key that light, heat and power were furnished in a way that was perfectly unaccountable. It was plain that electricity had become something more than a scientific toy. It was one of the great working forces of the world.

Long before that I had some opportunity to witness the wonderful flexibility of electricity in our own printing house. There was there a little humming dynamo whirling around at great rapidity, that was generating an unseen power, liberating atoms of copper, finer and purer than could be attained by fire heat, and making the exact duplicate of an engraving at about one-tenth of its cost, and I had good reason to be thankful that electricity had been applied to the art of typography. It was something more than a scientific toy there; it was doing work.

I shall not tire you, gentlemen, by telling you of the triumphs of electricity in other directions. You know the story a great deal better and can tell it better than I can; but I do think it is worth while to call attention to the fact that notwithstanding the advances which have been made in many directions of electric power, that there are some teachings of political economy which have not followed the development of machinery, which threaten to make some disturbance in the world; and it is on that point I want to make a few remarks. Horace, the old Latin poet, sharply divided the people of the world into two classes, those who grew corn and those who ate corn. Following this lead the political economists of the eighteenth century and many of the nineteenth, laid down the proposition that all work was the result of labor, and that labor has been understood erroneously by too many people as manual labor only. In my own trade every invention that has been made by science has been denounced at one time or another. At the introduction of the art of stereotyping, the rotary printing machine, the cylinder press, the type-setting machinet—hese inventions were stigmatized as "robbers of the poor," "taking the bread out of the poor people's mouths." The notion has gained currency, particularly among the more ignorant classes in our own community, that machinery is of great disadvantage to the laborer, that it has made the rich richer and the poor poorer. I dissent from that teaching; I reject it altogether. I contend that the wealth of the world has been increased by invention and machinery, and that their combined influence has tended, not to the debasement, but to the uplifting of labor. We have not outgrown the old false ideas which people entertained some hundred years ago. At that time every man who devoted himself to science and invention was looked upon as an idealist, a visionary and an enthusiast. The working class, if I can so call it, the laboring class, stuck to the idea that these men were practically parasites upon society, and that the working men were the ones who produced the wealth of the world. There never was a greater mistake. To help them to this wrong conclusion some of our writers, notably Ruskin and William Morris, have laid down the proposition that society was at its best when every man was his own employer and did not work for a factory or any aggregation of capital. This has been said in spite of the fact that there are places in the world, especially in the Far East, where there are no large factories, and where manufacturers do not employ

machinery, but in such places as in China, the manual laborers—many of them most expert of workmen—do not earn dimes where machine tenders here earn dollars.

Personally, I am acquainted with few of you, but I understand very well that you as electrical engineers are the conservers and controllers of one of the great working forces of the world. You are not capitalists and you are not manual laborers, and yet you are indispensable to both. Without you capital could do nothing. Without you labor would be only half-paid. Worse than that, without the machinery which you regulate the product of labor would be faulty, almost contemptible. And yet, notwithstanding all the benefit which has accrued to the world at large from invention and from machinery for the last fifty years, the unrest of labor is as great as ever. We have strikes continually. The future of society is threatened. It seems of very little use for any mechanic or any manufacturer to appeal to Congress or to Legislatures. The Legislatures as a general rule are inactive because their members are anxious to secure re-election by catering to the whims of the majority of voters. Samson Brass, one of Dickens' characters, says that the first axiom of the law is to look after itself. It follows that any tendency on the part of the public to stop litigation works great injury to lawyers and is not to be approved. Just so, the merchant and manufacturer can get very little help from the Church. The Church ought to be, by virtue of its mission, the great disseminator of the gospel of peace and good-will; and yet it is now, as it was more than a hundred years ago, when John Wesley said that he found it impossible to reach the two extremes of society—the very rich and the very poor. The Church could not keep its hold on them.

Now it is to you, gentlemen, according to my notion, that we have to look for the maintenance of peace and harmony during this century. As I have said before, you are not capitalists nor laborers, but you are indispensable to both. You are the intermediates that connect discordant forces. You have shown to capital that it is of little value unless there is skill, knowledge and efficiency on the part of the intermediate who secures from capital its due reward. You have shown to labor that it is quite possible for a person without capital or means to qualify himself for a position of profit and honor. Although capital has been called so hard and selfish, there is no class that is more willing to give generous acknowledgment to skill and fidelity. I look to you, gentlemen, as the great pacifiers of existing troubles between

labor and capital. I am sure you will join with me in wishing that the differences which now exist will come to an end. The time will come and it is not far off, when the manual laborer, encouraged by your example, will discern that his true interest is in the encouragement of science and invention, in making himself the ally of capital and machinery, and not its fractious enemy. No class can be more helpful than electrical engineers in the attainment of this result.

TOASTMASTER MARTIN:—The Library of the INSTITUTE at the present time does not include any bound volumes of newspapers. I believe, however, that owing to the rapid manner in which the daily press is becoming the expositor of electrical ideas, it will soon be found necessary to include in the collection at least some of the typically representative daily newspapers. There is none of us who takes up a newspaper in the morning who does not there learn some electrical fact of whose existence he never had the least suspicion. Such men as Sprague and Stanley and Edison and Tesla and Pupin, have all consulted the columns of the daily papers to find new ideas with regard to the possibility of inventions that had never before entered into their wildest contemplation. Dr. Bayles, who is with us to-night, represents this new journalism, and has the advantage over a great many of his compeers on the daily papers in being also an engineer. I wish from my heart that there were more men like Dr. Bayles connected with the daily press in this city, and it is one of the most encouraging factors, one of the most encouraging signs of the manner in which they regard engineering ideas and ideals, that they are willing to trust to such a man the treatment and discussion of the topics which lie nearest to us. It is therefore that I have much pleasure in introducing Dr. James C. Bayles, of the New York *Times*, who will speak to the toast "Electricity in the daily press."

DR. JAMES C. BAYLES:—Mr. President and Gentlemen: Lest it be supposed that in restraining a natural tendency to try a fall with the toastmaster to balance not merely my own account with him but the accounts of previous speakers whom he has introduced with airy persiflage, I fear the keen and pliant rapier of his wit, permit me to relate an incident which came under my notice while traveling in the East. It occurred in Abyssinia and, besides serving the purpose immediately in hand, is an interesting illustration of the survival of the Roman *lex talionis* among primitive peoples.

Two boys were playing in the shade of the sheltering palm when it was arranged that one of them should climb the tree to detach dates, while the other stood below to catch what fell. It chanced, however, that the boy in the tree lost his hold and it was he and not the dates which fell upon the boy below, hurting him greviously. The mother of the fallee, so to speak, hastened to the Cadi, demanding reparation. After hearing the complaint the Cadi decided that the plaintiff had a case, and decreed that her son, the original fallee, should climb the tree and, letting go, fall upon the other boy, the original faller, who was required to place himself in a suitable and receptive attitude on the ground and await what might happen to him. As I remember, the case was subsequently settled out of court.

This kind of Cadi justice is what the speaker at a dinner may expect who undertakes to have fun with the toastmaster. One who may speak as often as he likes and avails himself of this privilege by speaking a great deal oftener than other people like, has an unfair advantage. Much the better plan for the aggrieved speaker is to follow the excellent example of Brer Rabbit and "lay low" until things come his way. At some dinner at which I shall preside I shall send him a flattering invitation to attend and respond to a toast—and if he is prudent he will decline.

When such an invitation reached me I was told that my toast this evening would be "The technical end of the daily press." That was easy. There is no such end. I now learn that it is "Electricity and the daily press." That is another matter. However, the speaker on an occasion like this who is hampered by the metes and bounds of his toast, has much to learn about acceptable after-dinner oratory. When an expert is through with it, the fate of a toast should recall that of the fox who was found dead near Montclair the day after a meet of the Essex County Hunt, and was shown by the autopsy to have died from fatty degeneration of the tissues due to sedentary habits and lack of exercise.

The daily press does not aim to be technical. It deals with facts, and is quite content to leave to those for whom, like my esteemed friends of the technical press a daily is much too sudden, the leisurely consideration of the reasons for things which the public has forgotten. The qualifications of the technical journalist may not, as some have unkindly assumed, consist in the breadth of his misconception or the comprehensiveness of his misinformation, but he certainly knows a great many things

that are not so, and delights to share his possessions with the credulous reader, assuming, of course, that what he writes is read. Considering that all he knows of what is going on in the world he learns from the daily papers, the patronizing way in which he points out and corrects unimportant and accidental errors, chiefly in the use of an arbitrary and wholly artificial terminology, which have found their way into the hot stereotypes from which newspapers are printed, is very impressive, no doubt, but it suggests the boy at the grade crossing making faces at the express train. Before the boy has screwed his features into the contortion which he deems most expressive of the fact that he doesn't want to go anywhere, and would not ride on a train if he could, the express is a mile away, and the passengers really know nothing about it. The dailies have to generalize very quickly and do not claim to be inerrant; but they do get the news, and that never was and never will be the function of the technical journal. It has quite another purpose.

Judge Key, of Chattanooga, while Postmaster General in the Cabinet of President Hayes, invented a phrase which has outlived his other official service. It was that in which publications of a certain class are described as "primarily for purposes of advertising." This recalls a little story which I should not have had the heart to tell at a dinner presided over by a technical editor, had that gentleman been less indiscreetly facetious in his own remarks.

One day a gentleman from Texas visited New York and in the course of his rambles through the streets he chanced upon an organ grinder with a monkey. (I beg, Mr. Chairman, that you at least will believe that my anecdote is divested of all trace of personality.) The organ was covered with green baize, and on this sat the sad-faced Simian, waiting for what might eventuate. The habit of a lifetime had taught our Texan friend to associate a level surface covered with green cloth with some sort of a game of chance, so he marched up to the instrument and laid down a five dollar bill. The monkey promptly appropriated it, doffing his cap in the perfunctory fashion of his kind. The Texan shrugged his shoulders, remarked that one could not expect to win every time, and laid down another bill. This the monkey promptly pouched in turn, while the delighted musician turned the barrel of his organ as if it was coupled direct to a Parsons turbine. The Texan was not lacking in sporting blood, but he knew when he had had enough, and turned away remarking that

while he did not understand this particular gambling proposition he did not remember ever having been in a game in which the advantage seemed to be so largely with the dealer.

If I am reminded of this when I see the quantities of advertising the technical papers carry, it is of course because the association of ideas will sometimes bring unrelated suggestions into irrelevant juxtoposition. Of course they don't get much for it—but that, as Kipling would say, is another story.

The relation of electricity to the daily press is really much more intimate than might appear at first glance. To cable and land telegraphs we are indebted for a deluge of stuff, and the enormous expense attending its getting by the hundred agencies employed in collection and transmission leaves so little for the employment of writers of large experience and ripe judgment that we who belong in that classification have to struggle along on beggarly salaries of ten or twenty thousand dollars a year. Now, gentlemen, I ask you as man to man, what can you expect when literary talent is thus starved that bloated monopolies like the Anglo-American and the Western Union may bleed us as they do? Our hope is in Marconi's cent-a-word promise, and may he live until he " makes good."

For the ephemeral and sensational features of the daily press the electrician is to blame. For its influence for good, its incalculable power in shaping public opinion along right lines and its beneficient function in the upbuilding and safeguarding of civilization, the journalist who is proud of the fact that he knows no more about electricity than a cat knows about pearls, is entitled to the credit. When he disappears from the scene of action and leaves the world to regulate itself, anarchy will succeed order and chaos cosmos.

The characteristic and beautiful modesty of this statement will, I am sure, commend itself to your appreciation like the perfume of the violet or the bashful pendulosity of the lily of the valley.

It has been the pleasure of many writers, and among them none more charmingly than the late Charles Kingsley, to tell us how the hoarded sunshine of the early world, locked up in the lush vegetation of the carboniferous period, flashes forth again as light and heat when the carbon atoms of coal upon the fire rush to the embrace of the oxygen atoms they parted from when the world was young. We trace this perennial miracle in all the phenomena of combustion, and wonder at it. How much more

startling the transformation when the carbon of printers' ink is mingled with thought and, fired by the Promethian spark of inspiration, as light and power flashes from the printed page to illuminate the world and drive the wheels of industry with constantly accelerating speed. This is what happens when the clang of the press produces a daily paper.

But of the technical journals— Well, some of us may at times find ourselves repeating the sage remark of the little girl, " Mamma, I do love my donkey, but he'd be ever so much nicer if he wouldn't donk."

TOASTMASTER MARTIN:—While I sat here just now, a message came up from the floor that there were five or six excellent jokes to be had for a dollar and a half. I was trying to locate a possible purchaser at this board. Since I heard Bayles, my own mind is satisfied on the subject. But one word in parting. I promised our friend, Mr. Weaver, who is sick at home to-night, to bring with me one message from him, and that was if you happen to know a millionaire would you not please catch him and get something from him on behalf of the library; but you want to be sure of your millionaire. I remember a little incident in this city, at least it was in the daily papers, and therefore I give it due credit, with regard to an attempt made to collect a million dollars form a somewhat cold-blooded millionaire whose name, perhaps, it would not be sage to mention. The gentleman who had this loan in mind started out with a little dynamite in a handbag in order that, with its assistance, he might be able to dislodge the rocks. The dynamite was used with an explosion which left the vicinity of Trinity Churchyard something like a section of the New York subway. The millionaire emerged from the scene with his shirt front and his bank balance intact, but as for the would-be collector, from that day to this he has not been able to collect even himself. Other and more successful attempts have been made and there are those who have found a touch of our friend Weaver absolutely irresistible. There is no one whose generosity has been more deeply appreciated than that of Mr. Edward D. Adams, who is with us at this table to-night.

And now, ladies and gentlemen, with this word of advice, encouragement and good cheer, from our Chairman of the Library Committee, I have the honor to declare the " Second Annual Dinner " ended.

## AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

NEW YORK, February 27, 1903.

The 173rd meeting was held this date at 12 W. 31st Street.

President Chas. F. Scott called the meeting to order at 8:15 and said that the Secretary had an announcement to make:

SECRETARY POPE:—At the meeting of the Board of Directors this afternoon, the following one hundred and one Associates were elected:

| Name. | Address. | Endorsers. |
|---|---|---|
| ADAMS, HERBERT HARTER, | Tester, General Electric Co.; residence, 408 Union St., Schenectady, N. Y. | C. P. Steinmetz.<br>A. L. Rohrer.<br>E. B. Raymond. |
| AHLM, CHARLES EDWARD FRANS, | Electrical Engineer D. C. Dept., Bullock Electric Mfg. Co., Cincinnati, Ohio. | F. G. Bolles.<br>B. A. Behrend.<br>L. E. Bogen. |
| ALLEN, THOMAS SIMMONS, | Electrical Engineer, Bullock Electric Mfg. Co., Cincinnati; residence, 2039 West Sherman Ave., Norwood, Ohio. | F. G. Bolles.<br>B. A. Behrend.<br>L. E. Bogen. |
| ASCHOFF, ADOLPHO, | Partner James Mitchell & Co., Rio de Janeiro, Brazil. | Joseph Wetzler<br>T. C. Martin<br>M. A. Oudin. |
| BAEHR, WILLIAM ALFRED, | Superintendent, Gas Department, The Denver Gas and Electric Co., 405, 17th St., Denver, Colorado. | H. L. Doherty.<br>H. J. Gille.<br>C. F. Burgess. |
| BALLARD, FREDERICK WAYNE, | Electrical Editor, *The Engineer*, 24 Blackstone Building, Cleveland, Ohio. | F. C. Caldwell.<br>F. L. Hutchinson.<br>A. L. Rice. |
| BEDELL, RAYNER MONROE, | 20 North Mountain Ave., Montclair, N. J. | Frederick Bedell.<br>H. J. Ryan.<br>E. L. Nichols. |
| BIRCH, ARTHUR KNODE, | Sales Department, Bullock Electric Mfg. Co., Cincinnati, Ohio. | F. G. Bolles.<br>W. S. Franklin.<br>R. T. E. Lozier. |

| | | |
|---|---|---|
| BISSELL, FREDERICK, | President. The F. Bissell Co., 226 Huron St., Toledo, Ohio. | E. J. Bechtel.<br>E. P. Roberts.<br>A. J. Wurts. |
| BRAGA, EDUARDO, JR., | Student in Electrical Engineering, Polytechnic Institute; residence, 242 De Kalb Ave., Brooklyn, N. Y. | S. W. Ashe.<br>Samuel Sheldon.<br>W. L. Sturgis. |
| BROOKS, FRANK HARRISON, | General Manager, Vicksburg R. R. Power and Mfg. Co., Vicksburg, Miss. | James Lyman.<br>T. P. Gaylord.<br>E. W. Lloyd. |
| BROOKS, ORION, | Manager Electric Engineering Department, Heald's School of Mines and Engineering, 24 Post St.; residence, 231 Capp St., San Francisco, Cal. | G. P. Low.<br>W. W. Hanscom.<br>F. E. Smith. |
| BROWNE, MORTON S., | General Contracting Agent, Columbus Edison Co., Columbus, Ohio. | L. G. White.<br>A. W. Field.<br>A. B. Herrick. |
| BULLOCK, GEORGE, | President, Bullock Electric Mfg. Co.; residence, 2915 Vernon Place, Cincinnati, Ohio. | F. G. Bolles.<br>B. A. Behrend.<br>R. T. E. Lozier. |
| BUSHNELL, S. MORGAN, | Engineer, Chicago Edison Co., 139 Adams St.; residence, Hyde Park Hotel, Chicago, Ill. | E. W. Lloyd.<br>W. G. Carlton.<br>W. L. Abbott. |
| CAHOON, WILLIAM HAMBLIN, | Constructing Engineer, and Tester, Bullock Electric Mfg. Co.; residence, 4905 Wesley Ave., Station H, Cincinnati, Ohio. | F. G. Bolles.<br>B. A. Behrend.<br>W. D. Pomeroy. |
| CARPENTER, HUBERT VENTON, | Professor of Mechanical Engineering, Washington Agricultural College, Pullman, Wash. | W. S. Aldrich.<br>William Esty.<br>B. V. Swenson. |
| CHALMERS, CHARLES HENRY, | Vice-President and General Manager, Electric Machinery Co.; residence, 2640 Essex St., Minneapolis, Minn. | G. D. Shepardson.<br>Morgan Brooks.<br>E. P. Burch. |
| CLARKE, JAMES ULRICK, | Superintendent Lancaster Traction Co., Lancaster, Ohio. | F. G. Bolles.<br>W. D. Pomeroy.<br>B. A. Behrend. |
| COLE, ROBERT CHARLES, | Assistant to Electrical Engineer, The Johns-Pratt Co.; residence, 201 Farmington Ave., Hartford, Conn. | R. W. Pope.<br>E. C. Boynton.<br>N. H. Heft. |
| CRAIG, THOMAS EDGAR, | Salesman, General Electric Co., 200 Summer St., Boston; residence, 256 So. Common St., Lynn, Mass. | R. Fleming.<br>H. W. Hillman.<br>R. W. Pope. |
| CRONVALL, ERIK, | Electrical Draftsman, New York Edison Co., 55 Duane St., New York City. | C. O. Mailloux.<br>C. E. Carpenter.<br>J. W. Lieb, Jr. |

| | | |
|---|---|---|
| Cross, Edmund Rust, | Dynamo Testing Department; residence, 1116 South Ave., Wilkinsburg, Pa. | S. G. Peticolas. H. B. Smith. J. S. Peck. |
| Dodd, John Nevins, | Designer of Electrical Machinery, English Electrical Mfg. Co., West Strand Road, Preston, Lancashire, England. | A. P. Zani. S. T. Dodd. W. Rutherford. |
| Dow, James Chase, | Switchboard Attendant, Missouri River Power Co., Canyon Ferry, Mont. | M. H. Gerry, Jr. G. D. Shepardson. E. P. Burch. |
| Eaton, Howard French, | Mechanical and Electrical Draftsman, Stone & Webster, 19 High St., Boston; residence, Quincy, Mass. | Russell Robb. A. L. Riker. T. D. Lockwood. |
| Edgar, Harry Thomas, | Manager El Paso Electric Railway Co., and International Light and Power Co., El Paso, Texas. | L. Stieringer. T. C. Martin. W. S. Barstow. |
| Eglinton, William McNicol, | Chief Constructing Engineer of Power Plant, Guanica Centrale, Guanica, Porto Rico. | D. A. Palmer. E. A. Merrill. M. L. Mora. |
| Elshoff, Bernard, | General Foreman, Bullock Electric Mfg. Co., East Norwood; residence, 1522 Breman St., Cincinnati, Ohio. | F. G. Bolles. W. D. Pomeroy. B. A. Behrend. |
| Foster, George Beers, | District Manager, Bullock Electric Mfg. Co.: 1625 Marquette Building; residence, 527 La Salle Ave., Chicago, Ill. | R. H. Pierce. S. G. Neiler. B. J. Arnold. |
| Fuller, Arthur John, | Burgh Engineer, Corporation Electric Works, 18 Carrick Park, Ayr N. B., England. | Wm. Maver, Jr. H. A. Lardner. F. W. Roller. |
| Gerdes, Theodore Richard Nicholas, | Rodman, Rapid Transit Construction Co.; residence, 5 Van Nest Place, New York City. | A. F. Ganz. W. E. Geyer. W. C. Bamber. |
| Gillette, James Walter, | General Manager and Resident Engineer, Phœnix Gas and Electric Co., Phœnixville, Pa. | J. B. Cahoon. B. J. Arnold. G. A. Damon. |
| Goodell, John M., | 34 May St., Worcester, Mass. | E. O. Sessions. W. D. Weaver. N. S. Hill, Jr. |
| Gray, Latimer D., | Electrical Engineer, Union Pacific Coal Co., Rock Springs, Wyoming. | C. J. Reed. H. R. Wellman. T. B. Whitted. |
| Gray, Vance I., | Engineer and Salesman, The F. Bissell Co., Toledo, Ohio. | W. N. Zurfluh. G. D. Shepardson. E. J. Bechtel. |

| | | |
|---|---|---|
| GUTBROD, FRIEDRICH WILHELM, | Electrical Engineer, Berlin W. 35 6 Derffling St., Germany. | C. P. Steinmetz.<br>M. A. Oudin.<br>L. C. Marburg. |
| HAVILAND, HENRY FIELD, | Tester, General Electric Co.; residence, 101 State St., Schenectady, N. Y. | F. B. Crocker.<br>G. F. Sever.<br>W. I. Slichter. |
| HOLMAN, MINARD LAFEVER, | General Superintendent, Missouri Edison Electric Co.; residence, 3744 Finney Ave., St. Louis, Mo. | H. H. Humphrey.<br>G. F. Durant.<br>F. E. Bausch. |
| HONEY, WILLIAM, | Electrical Engineer, The Mexican Gas and Electric Light Co., Station Clara No. 7, Mexico City, Mexico. | C. F. Beames.<br>E. L. Simpson.<br>F. O. Renstrom. |
| HONNOLD, ORVILLE A., | Division Engineer, Utah Light and Power Co., Salt Lake City, Utah. | P. H. Thomas.<br>L. S. Boggs.<br>E. M. Tingley. |
| JAMES, TUDOR CONWAY, | Electrical Engineer, Michigan and Lake Superior Power Co., Sault Ste. Marie, Mich. | E. O. Sessions.<br>L. D. Bliss.<br>R. D. Lillibridge. |
| JOHNS, ELLWOOD C., | Electrician, The United Electric Light and Power Co., of N. J.; residence, 161 Virginia Ave., Jersey City, N. J. | J. T. Lawson.<br>J. B. Barr.<br>B. K. Hough. |
| JOHNSON, CHARLES WOOD, | Production Manager, Bullock Electric Mfg. Co.; residence, 2272 Jefferson Ave., Norwood, Ohio. | F. G. Bolles.<br>William Cooper.<br>B. A. Behrend. |
| JOHNSON, MONTGOMERY HUNT, | President, Johnson & Morton, 44 Whitesboro St., Utica, N. Y. | T. C. Martin.<br>W. W. Nicholson.<br>H. B. Coho. |
| JOLY, HENRI LOUIS, | Battery Expert and Chemist, The Electromobile Co., Ltd.; residence, 89 Edith Grove, Chelsea, London, S. W., England. | H. F. Parshall.<br>W. J. Hammer.<br>T. C. Martin. |
| KAETKER, HENRY, | Foreman of Switchboard and Controller Department, Triumph Electric Co.; residence, 3561 Coleraine Ave., Cincinnati, Ohio. | C. S. Reno.<br>S. R. Kerr.<br>R. W. Pope. |
| KARAPETOFF, WALDIMIR, | Special Apprentice, Westinghouse E. & M. Co.; residence, 804 Wood St., Wilkinsburg, Pa. | C. F. Scott.<br>L. A. Osborne.<br>J. S. Peck. |
| KATTE, EDWIN BRITTON, | Electrical Engineer, N. Y. C. & H. R. R. R. Co.; Grand Central Station, New York City; residence, Irvington, N. Y. | B. J. Arnold.<br>F. J. Sprague.<br>Eugene Griffin. |
| KIRKER, HARRY LEPPER, | Estimating and Erecting Engineer, The British Westinghouse E. & M. Co., Ltd., Westinghouse Building, Strand, London, England. | C. F. Scott.<br>Albert Schmid.<br>R. W. Pope. |

| | | |
|---|---|---|
| KNIGHT, EARL RAWLINGS, Engineer, Bullock Electric Mfg. Co., Norwood, Ohio. | F. G. Bolles. | W. D. Pomeroy. | B. A. Behrend. |
| LANG, EDMUND, in charge Advertising Department, H. B. Coho & Co., 114 Liberty St., New York City; residence, 59 Howard Ave., Brooklyn, N. Y. | H. B. Coho. | E. L. Phillips. | W. N. Smith. |
| LINZEE, ALBERT CARL, Designing Engineer, General Electric Co.; residence, 1 Division St., Schenectady N. Y. | William Esty. | A. E. Averett. | H. G. Reist. |
| LOWENBERG, LAURENT, Head of Specification Department, Bullock Electric Mfg. Co.; residence, 2229 Park Ave., Cincinnati, Ohio. | F. G. Bolles. | W. D. Pomeroy. | B. A. Behrend. |
| LUNDY, AYRES DERBY, Electrical Engineer, Sargent and Lundy, 46 E. Van Buren St., Chicago, Ill. | James Lyman. | D. C. Jackson | Arthur Hartwell. |
| MALLET, JOHN PURINTON, Chief Engineer and Designer, Northern Electric Mfg. Co.; residence, 223 N. Carroll St., Madison, Wis. | T. E. Drohan. | C. F. Scott. | P. H. Thomas. |
| MARSH, CHARLES MERCER, Student, Cornell University; residence, 519 East Buffalo St., Ithaca, N. Y. | H. J. Ryan. | A. S. McAllister. | G. S. Macomber. |
| MERRILL, FREDERICK L., Engineering Salesman, Standard Railway Materials Co., 403 Omaha Building; residence, 1158 Flournoy St., Chicago, Ill. | R. H. Pierce. | B. J. Arnold. | L. A. Furgeson. |
| MUDGE, CHARLES A., Ober-Engineer, Direct Current Railway Department, Allgemeine Electricitats, Gesellschaft, Ackerstr 71, Berlin, Germany. | Robert Lundell. | F. A. Scheffler. | E. R. Knowles. |
| NAGEL, WILLIAM G., President and Manager, The W. G. Nagel Electric Co., 520 Adams St., Toledo, Ohio. | C. F. Scott. | B. F. Thomas. | F. C. Caldwell. |
| NEAVE, JOSEPH SWAN, Vice-President, Bullock Electric Mfg. Co., Grandin Road, Cincinnati, Ohio. | F. G. Bolles. | B. A. Behrend. | W. D. Pomeroy. |
| NIETHAMMER, FRIEDRICH, Professor of Electrical Engineering Technische Hochschule, Brünn, Austria. | C. P. Steinmetz. | E. W. Rice, Jr. | E. J. Berg. |
| NORRIS, HENRY HUTCHINSON, Assistant Professor of Electrical Engineering, Cornell University, Ithaca, N. Y. | W. S. Aldrich. | J. B. Scott. | H. J. Ryan. |
| OLIN, EDWIN MASON, Engineer Foreman in charge Testing Department, Westinghouse E. & M. Co., Pittsburg; residence, 1112 Center St., Wilkinsburg, Pa. | W. A. Dick. | C. F. Scott. | P. A. Lange. |

| | | |
|---|---|---|
| PENTON, CARL TOWNLEY, | Chief Electrician American Ship Building Co.; residence, 222 Forest St., Lorain, Ohio. | C. H. Hines.<br>C. R. Huntley.<br>E. D. McCarthy. |
| PERRY, FRANK ELLIS, | Salesman, Bullock Electric Mfg. Co.; residence, 21 East 7th St., Cincinnati, Ohio. | F. G. Bolles.<br>B. A. Behrend.<br>W. D. Pomeroy. |
| PHARO, HARRY ALEXANDER, | Electrical Superintendent, Trade Dollar Mining Co., Dewey, Idaho. | C. F. Scott.<br>R. W. Pope.<br>P. H. Thomas. |
| PHILLIPS, WALTER, | Manager, Westinghouse Electricitats Actien Gesellschaft, 19 Jacger Strasse, Berlin, Germany. | C. F. Scott.<br>J. F. Easterbrook.<br>L. A. Osborne. |
| RAU, OTTO MARTIN, | Chief Electrician and Superintendent, Lighting Department, The Milwaukee Electric Railway and Light Co., Milwaukee, Wis. | James Lyman.<br>Wm. Goltz.<br>Joseph Sachs. |
| REINHART, WILLIAM JEFFERIS, | Student, Cornell University; residence, 205 Huestis St., Ithaca, N. Y. | A. S. McAllister.<br>H. J. Ryan.<br>Frederick Bedell. |
| ROBERTS, SHELDON, | Inspector, Columbus Edison Co. residence, 137 W. Goodall St., Columbus, Ohio. | L. G. White.<br>F. C. Caldwell.<br>A. W. Field. |
| ROBINSON, LAFOREST GEORGE. | Engineer and Inspector in charge of Terminal Station, Shawinegan Water Power Co., Montreal, Can.; residence, Cincinnati, Ohio. | B. A. Behrend.<br>L. E. Bogen.<br>R. T. E. Lozier. |
| ROETTINGER, ED. MARSH, | Night Foreman Test Department, Bullock Electric Mfg. Co.; residence, 630 West 8th St., Cincinnati. | F. G. Bolles.<br>B. A. Behrend.<br>W. D. Pomeroy. |
| ROLF, ARTHUR F., | Sales Engineer, Bullock Electric Mfg. Co.; residence, 3227 Beresford Ave., Walnut Hills, Cincinnati, Ohio | F. G. Bolles.<br>B. A. Behrend.<br>R. T. E. Lozier. |
| ROWE, GEORGE CLARENCE, | Electrical Engineer, Cia de Electridad de Cuba, Aguiar 81, Havana, Cuba. | E. R. Weeks.<br>J. M. Kent.<br>R. W. Pope. |
| SCHLUSA, KURT, | Electrical Engineer, Tacoma Railway and Power Co., Box 700, Tacoma, Wash. | J. D. Mortimer.<br>A. C. Babson.<br>W. A. Lynn. |
| SCHNUCK, EDWARD FREDERICK, | General Superintendent, Arbuckle Bros., Old Slip and Water St., N. Y. City; residence, 119 E. 19th St., Brooklyn, N. Y. | C. O. Mailloux.<br>F. C. Bates.<br>R. G. Brown |
| SCHWARTZ, CARL, | Electrical Engineer, Chicago Edison Co., 139 Adams St.; residence 1836 Michigan Ave., Chicago, Ill. | P. Junkersfeld.<br>L. A. Ferguson.<br>W. G. Carlton. |

SCHWERMER, FELIX THEODOR, Construction Engineer, General Electric Co., Schenectady, N. Y., now with Mexico Gas and Electric Co., St. Lanow Station, City of Mexico. — C. F. Beames. W. G. Ely. Ralph W. Pope.

SENSTIUS, SEBASTIAAN, Electrical Engineer, Bullock Electric Mfg. Co., Cincinnati, Ohio. — F. G. Bolles. B. A. Behrend. W. D. Pomeroy.

SHAAD, GEORGE CARL, Instructor in Electrical Engineering Department, University of Wisconsin; residence, 412 N. Carrol St., Madison, Wis. — B. V. Swenson. D. C. Jackson. J. P. Jackson.

SOUTHWORTH, MARTIN O., Chief Engineer, Commercial Electric Co., Indianapolis, Ind. — C. W. Rice. J. B. Baker. J. B. Blood.

SPENCER, FREDERICK FURMON, Assistant Engineer, Mexico General Electric Co., Mexico City, Mexico. — C. F. Beames. T. E. Theberath. L. M. Hancock.

SPIER, CHARLES L., Vice-President, S. I. Midland R. R. Co., 26 Broadway, New York City; residence, 7 Tompkins Ave., New Brighton, S. I., N. Y. — H. A. Foster. J. B. Cahoon. M. J. Wightman.

SPURLING, OLIVER CROMWELL, Factory Engineer, Western Electric Co., North Woolwich, Eng.; residence, 3 Charlton Road, Blackheath, London, Eng. — H. F. Albright. G. A. Hamilton. G. F. Atwood.

SUNNY, BERNARD EDWARD, Western Manager General Electric Co.; residence 138 Astor St., Chicago, Ill. — R. H. Pierce. Eugene Griffin. B. J. Arnold.

SWITZER, GEORGE H., Superintendent of Constructon, Morgantown Electric and Traction Co., Morgantown, W. Va. — W. K. Dunlap. J. L. Merrill. F. L. Hutchinson.

TATUM, LEWIS LEEDS, General Storekeeper, Bullock Electric Mfg. Co., Norwood, Ohio. — F G. Bolles. H. J. Ryan. R. T. E. Lozier.

THOMPSON, HARRISON GILMAN, JR., Electrician, Bliss Electric Car Lighting Co., 1 Nassau St., residence, 159 W. 3d St., Bayonne, N. J. — W. L. Bliss. J. R. Sloan. R. W. Pope.

THURBER, GUY PLUMMER, Engineer, Salesman and District Manager, Bullock Electric Mfg. Co.; residence, 621 N. Euclid Ave., Pittsburg, Pa. — F. G. Bolles. B. A. Behrend. W. D. Pomeroy.

TURNER, MATHIAS EVERETT, Electrical Engineer, Cleveland Electric Illuminating Co., 711 Cuyahoga Building, Cleveland, Ohio. — Robert Lindsay. E. J. Bechtel. C. D. Haskins.

| | |
|---|---|
| VAN NORDEN, RUDOLPH WARNER, Superintendent and Engineer, Central California Electric Co.; residence, 1003 K St., Sacramento, Cal. | F. A. C. Perrine.<br>C. F. Scott.<br>J. A. Lighthipe. |
| VAUGHN, JOHN FAIRCHILD, General Engineer, Stone & Webster, 93 Federal St., Boston; residence, 30 Walker St., Cambridge, Mass. | C. A. Stone.<br>N. H. Heft.<br>W. L. Robb. |
| WAKEMAN, JAMES MEANLEY, Manager *Electrical World and Engineer*, 114 Liberty St.; residence, 118 Washington St., East Orange, N. J. | T. C. Martin.<br>H. W. Blake.<br>W. D. Weaver. |
| WARREN, WILLIAM HENRY, Electrical Engineer, Western Electric Co , 259 So. Clinton St., Chicago, Ill. | Robert Lundell.<br>William Cooper.<br>R. T. E. Lozier. |
| WATSON, GEORGE HATHON, President, The Northern Engineering Co., 95 Liberty St., New York City; residence 184 Carroll St., Paterson, N. J. | August Parshall.<br>H. B. Coho.<br>F. S. Blackall. |
| WELCH, FRANK PHILLIP, Electrical Engineer, Ingarian Mining Co., Rebeldes No. 2, City of Mexico. | C. F. Beames.<br>S. A. Dyer.<br>R. W. Pope. |
| WESSLING, ALBERT GUSTAVE, Chief Engineer, Bullock Electric Mfg. Co.; residence, 549 Milton St., Cincinnati, Ohio. | F. G. Bolles.<br>B. A. Behrend<br>William Cooper. |
| WILLIAMS, CLEON L., City Electrician and Superintendent, F. A., City of Meridian, Meridian, Miss. | William Brophy.<br>Adam Bosch.<br>R. W. Pope. |
| WILLIAMS, HERBERT HOWARD, 183 Columbia Heights, Brooklyn, N. Y. | Samuel Sheldon.<br>T. E. Murray.<br>Henry Floy. |
| WOLFF, SALOMON, Night Foreman, Testing Department, Bullock Electric Mfg. Co.; residence, 1214 Westminster Ave. Cincinnati Ohio. | F. G. Bolles.<br>R. W. Pope.<br>B. A. Behrend. |

Total 101.

At the meeting of the Board of Directors this afternoon, the date of the annual convention which was given in the February Announcement as June 22–26, at Niagara Falls, was changed to June 29th to July 3d, one week later, owing to the fact that other very large conventions were to be held at Niagara Falls during the week first selected, and suitable hotel accommodations could not be obtained during that week for the meeting of the INSTITUTE.

*A paper read at the 173d Meeting of the American Institute of Electrical Engineers, New York, February 27th, 1903.*

# RAILWAY TRAIN LIGHTING.

## INTRODUCTION BY PRESIDENT SCOTT.

A gentleman whose whitened hair indicated that he has passed his three-score years and ten, recently gave me a most interesting account of his wedding journey some fifty years ago from Western Pennsylvania to Philadelphia. It was a story of travel on stage coaches and canal boats for nearly a week. The particularly impressive point was the change which has taken place in the mode of travel, not only in speed but in comfort and convenience. We take it as a matter of course that our trains are not only to be comfortable and convenient in their various appointments, but that they are to be replete with the luxuries of the drawing-room and the parlor, the dining room and the sleeping apartment. Those of us who are in early or middle life may know nothing of the stage coach, but we can easily recall some of the earlier conditions of train equipment, for it has been only a few years since three or four oil lamps which did little more than make visible the outlines of the interior of a car, were replaced by systems of gas lighting.

The electric light is in many respects the ideal light for train illumination. The light is brilliant, it may be generously distributed in small units, it contributes little to the heating and nothing to the vitiation of the air, it is under easy control and in emergency or accident there is not the liability to cause fires that is possessed by oil or gas.

The electric problem is in one sense a very simple one—a small number of lamps such as are found in an ordinary residence or office is to be supplied by current. On the other hand, the problem of supplying the necessary current to these lamps is a pecu-

liarly intricate and difficult one. The only practical source of current is a generator from which the current must come either directly or through a storage battery. The simplest equipment is probably the storage battery located upon each car, which is charged or replaced at stations or lay-over points. The arrangement is comparable to the electric automobile except that the demands upon the train battery are not subject to the severe and irregular service which falls to the lot of the automobile battery. The arrangements for the charging of the batteries are apt to be, to say the least, somewhat inconvenient and expensive and the battery itself may be of a considerable weight, if it is to be in service for long periods without recharging.

If an engine-driven generator be placed upon the train, it may receive steam from the locomotive, or the engine may have its own fuel supply. Dependence upon steam supply from a locomotive is not easily practicable if a continuous supply of current is to be obtained, nor does a generating plant upon a single car of a train, even if it have its own fuel supply, allow the ready shifting of cars and making up of trains, unless there be a storage battery auxiliary. A generating unit upon each car is apt to be expensive and add to the general complication of the equipment.

A generator driven from the car axle by the motion of the train involves the operation of an essentially constant voltage machine from a variable speed drive having wide and irregular variations, as well as periods of rest. The problem, therefore, is a most difficult one as the supplying of a small amount of energy to a few lamps cannot by our present methods of converting energy be conveniently effected from any available source.

The fact that current for train lighting is obtained by one means or another demonstrates the facility which inventors and engineers possess for overcoming difficult problems, and it also emphasizes the value attached to electric light. The fundamental difficulty lies in the fact that the available methods of transforming energy and of storing electrical energy are so cumbersome and inadequate. The very difficulties are an appeal for new methods, for simple and efficient methods of transforming energy from its abundant and convenient sources into the desired form of electrical current. The motion energy of the train is almost infinite compared with the meagre amount of energy required for a few glow lamps, but apparatus for transforming, regulating and storing that energy is complicated and costly. The chemical energy contained in a few pounds of coal would be

ample for the evening lighting of a whole train, could it be efficiently transformed into electrical energy. An ice machine by which the heat in a pail of water could be abstracted in the form of electrical energy, would illuminate a car during a long journey as a lump of ice was being frozen.

The problem of train lighting is of general interest, aside from the specific interest which there is in following the details of systems by which the illumination may now be accomplished. It indicates the admirable adaptation of electricity through the incandescent lamp for contributing to the safety, the convenience and the luxury of travel. It presents most peculiar and exacting conditions with respect to the supplying of current which do not render our present sources of current readily applicable. And it further shows the inadequacy and the limitations of our present methods of transforming energy and the possibilities which await scientific investigation, discovery and invention in unexplored fields.

*A paper presented at the 173d. Meeting of the American Institute of Electrical Engineers, New York, February 27th, 1903.*

# AN ELECTRIC CAR LIGHTING SYSTEM.

BY W. L. BLISS.

A description of an axle-driven electric car lighting system in which the generator is located on the truck frame, the armature being rotated by means of a single reduction gearing. Explanation of the mechanical construction of the generating apparatus and the method of controlling the electrical energy under all conditions of railway service.

In presenting this paper, the author assumes that the members of the INSTITUTE are generally familiar with the subject of train lighting from the axle, and that no allusion to the previous state of the art, or the many failures and disappointments along this line of engineering is necessary or desirable. The admirable papers of Brown, Bauer, Blodgett and others have familiarized the members of the INSTITUTE with the work that has been done in the past and the degree of success that has been attained. It is with this thought in mind that the author will present for your consideration a modern method of train lighting from the axle that is reliable in its operation, and which has passed beyond the experimental to the commercial stage, and is becoming standard railway equipment.

This system consists essentially of the following elements:

1.—A dynamo electric machine or generator located on the car, or, as is the common practice in this country, directly on the truck frame, and so arranged that its armature is caused to rotate by means of a mechanical connection with the axle.

2.—Translating devices within the car, consisting in general of incandescent lamps and fan motors, and which utilize the electrical energy developed in the generator.

3.—A storage battery carried on the car, whose special function is to supply the electrical energy necessary to operate the lamps whenever the armature of the generator revolves at a speed too low to render the same operative, or when the armature ceases to rotate, which condition is obviously attained when the car is at rest.

4.—Auxiliary automatic apparatus, which, acting in conjunction with the above, will render the operation of the entire system automatic, safe and reliable.

## The Problem.

In attempting to attain the results indicated above, a multitude of difficulties present themselves which may be classified into two primary groups: (*a*) those which are purely mechanical and are concerned with the motive power, and which must be overcome before the generator can be operated successfully; and (*b*) those which appertain to the control of the electrical energy after it is developed and which are principally of an electrical nature, although involving no small application of mechanics.

The difficulties under group (*a*) arise from the peculiar character of the source of power, the location of the generator and the conditions under which the latter must operate.

As the generator in this system is located on the truck frame there must first be provided a machine mounting, and axle connection which shall withstand the injury and abuse coincident with the most exposed position in which a piece of electrical apparatus can be placed. Secondly, there must be provided an axle connection which shall not necessitate any change in the manufacture of standard railway axles. Such axles are rough, tapered and out of true, and no connection which contemplates the use of keys, set-screws, etc., or which requires turning, truing or machining the axle in any way will be permitted by railway officials. The reasons for this are obvious and require no further comment. (See Fig. 1.)

## Method of Driving.

In this system the generator and driving mechanism are modeled somewhat on the lines of the modern street railway motor, such modifications and additions being introduced as to adapt the apparatus to the special work in hand. A single reduction, gear-driven generator has been adopted, but, unlike the ordinary street-car motor, the entire weight of the machine is carried on the truck frame, it not being possible to journal on the axle, for the latter, as previously indicated, is not, nor will present railway practice permit it to be suitably prepared.

Instead of journaling the axle in bearings attached to the frame of generator, two large brackets are carried out from the frame

FIG. 1.

or casing of the generator and are adapted to receive and support a hollow shaft, which runs on roller bearings, and upon which the

split gear which meshes with the armature pinion is mounted. The hollow shaft, as well as the brackets, is divided longitudinally, in order to permit assembling on the car truck. The car axle extends through the hollow shaft, a clearance of nearly two inches all around the axle, and between it and the hollow shaft being provided. (See Fig. 2.)

FIG. 2.

This clearance permits the axle to take all manner of motions and positions (within certain limits), with reference to the hollow shaft. Only one component of the axle's motion is transmitted to the hollow shaft, this component being that of rotation. All other motions, the horizontal, vertical and end shake, being pro-

vided for in a positive though flexible connection between the axle and the hollow shaft. This consists of a two-armed dog clamped on by four bolts securely upon the axle, and four specially constructed driving-springs which are attached by means of ball-and-socket fastenings to the two ends of the dog, and to the two arms of the hollow shaft.

The driving-springs are of the "keg" or helical type, wound with tapered ends, and are mounted in shallow cups, through which are screwed ball-ended bolts, which form a part of the ball-and-socket fastening referred to. Inside the springs, the bolts are threaded and provided with nuts and conical washers which fit the inside of the tapered ends of the springs. The nuts are set up with a spanner wrench and locked with spring cotters. An opening is cast in each end of the dog, through the jaws or sides of which a bolt passes, and in this opening and secured by the bolt is a socket-casting split in a vertical plane. The casting projects on each side of the dog and is hollowed out at each end like a bullet mould, thus forming two spherical seats or sockets, into which the ball-ended bolts of the driving-springs fit. The two halves of this socket-casting are fastened together by four $\frac{3}{8}''$ bolts, to prevent their opening and allowing the balls to wear on the joint between them. Similar socket-castings are secured to the two arms or cranks of the hollow shaft by means of bolts or studs which act as crank-pins. All these castings and fittings are interchangeable. Each driving-spring is connected by means of the ball-ended bolts to a socket-casting on the dog, and one on the hollow-shaft arm. The springs are, initially, neither in compression nor extension, which feature greatly facilitates assembling. The ball-and-socket joints not only admit of the springs assuming all possible angles and positions, but enable them to act either in compression or tension while driving. Two diametrically opposite springs are in compression, while the other pair are in tension, and *vice versa*, depending on the direction of rotation of the axle and hollow shaft. (See Fig. 3.)

The dog need not run true, and no special care need be exercised in mounting it on the axle, it being quite as effective when not so true as when nicely adjusted. The dog is made of malleable iron and cast to fit the taper of the axle. There is a positive advantage in not carrying any of the weight of the generator on the car axle. Supported as the generator is, entirely on the truck frame, it is free from the shock, vibration and pounding which would be communicated to it were it journaled on the axle, as in a street

railway motor. It is very easy with this construction to put the generator out of operation by simply taking the dog off the axle. But the greatest advantage which results from this construction is the absence of necessity for trueing up anything in installing the machine. An approximate centering of the axle in the hollow shaft, and the coarsest kind of work in mounting the dog on the axle, are all that are necessary. All the trueing and lining up are done in the shop, and no knowledge of machine work is required of those who install the machine.

All parts of the mechanism which require it are thoroughly

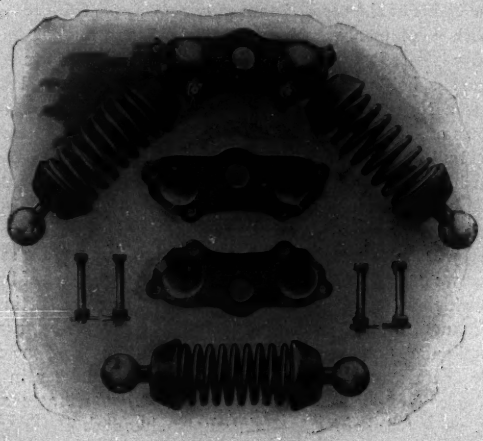


Fig. 3.

encased or otherwise protected. Automatic and profuse lubrication of the shaft bearings is provided. A cut steel gear on the hollow shaft drives a fibre pinion on the armature shaft. In consequence, these are run dry without lubrication of any kind, which conduces much to the cleanliness of the apparatus. See Fig. 4.

### The Generator.

The generator is of the ironclad type, having four internal radial salient poles. The poles are placed at an angle of 45°, with the horizontal, two poles being in the upper, and two in the lower half of the generator, which is divided longitudinally in a

horizontal plane. The casing which forms the yoke of the fields, is extended parallel with the axis of the shaft and is then turned in at right angles thus forming ends, so to speak. These ends are

FIG. 4.

bored out and have fitted into them round head-like castings which hold the armature-shaft bearings and oil-wells. When these heads are in place, the generator is almost hermetically

sealed, and is absolutely dust and water proof. Suitable hand-holes or doors are provided in the generator casing for purposes of inspection, etc. The two heads which carry the armature bearings are each held in place by four bolts, two of which are tapped into the upper half of the generator casing and two into

FIG. 5.

the lower. By this construction the lower half of the generator may be removed, leaving the armature in the upper half, or the armature may be removed with the lower half. The heads being nicely fitted to the casing, ensure the perfect alignment of the armature shaft, no steady pins or other trueing devices being

required. By removing the head-casting at the commutator end of the generator, and detaching the flexible cables from their respective brush-holders, the entire brush mechanism, to be described later on, may be removed without disturbing any of the working parts. See Fig. 5.

The armature is of the 4-pole drum type, having a two-circuit singly re-entrant drum-winding of the straight-cut or barrel type. The coils are wound on formers and afterward placed on the armature, thus providing a perfectly balanced winding both

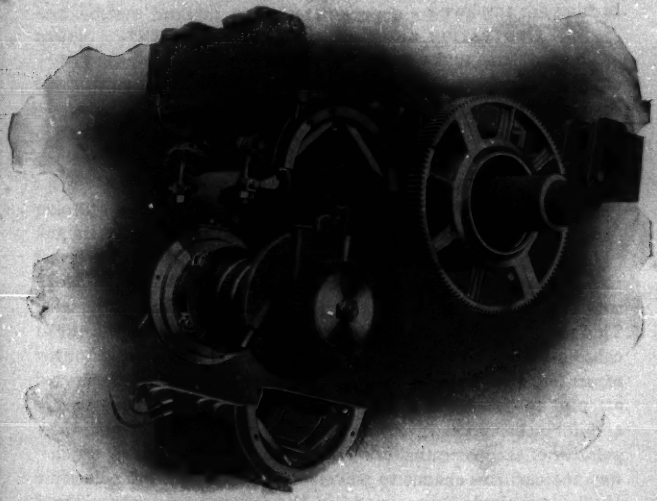


FIG 6

electrically and mechanically. The core of the armature consists of the usual annular stampings, slotted to receive the coils, and mounted on a ventilated spider. The central portion of the spider forms a sleeve which is extended at one end to support the commutator. The sleeve is bored out to take the armature shaft, which is suitably keyed and otherwise secured. This arrangement permits the armature and commutator to be quickly taken off the shaft without disturbing the windings, thus affording a ready means for making repairs either to the shaft or to the

armature itself. The construction of the armature, shaft and commutator is extremely substantial. All the running parts are heavily proportioned, and are designed to resist the heaviest shocks and stresses. The generator is connected as a plain shunt-wound machine and is self-exciting. Hence, there is but a single winding on the field, each pole being excited by one coil. See Fig. 6.

The armature winding, being of the two-circuit type, requires but a single pair of brushes to take the current from the commutator, but, for purposes hereinafter explained, two pairs of brushes are employed.

### Generation and Control of the Current.

The problems under group (*b*), as previously stated, are principally of an electrical nature. Being provided with a generator driven by the car axle which will supply the required electrical energy to operate the lamps and charge the storage battery, there are four conditions which must be electrically and mechanically provided for, and the operations they entail automatically performed, before the system can be declared operative.

### The Pole Changer and Automatic Brush Mechanism.

*First.*—Provision must be made for the fact, that the direction of travel of the car will be reversed, and hence the direction of rotation of the armature of the generator will suffer a reversal. This would render a self-excited generator inoperative, or would cause a reversal in the polarity of the brushes or terminals of a separately excited machine. It being highly improper to attempt to charge the storage battery with a reversed current, and for other reasons, means must be provided whereby the polarity of the generator terminals is preserved, no matter which way the car may chance to travel. In this system, the polarity of the terminals is preserved in the following manner: The brush-holders are mounted on a carrier, which is supported on anti-friction bearings, which enable it to rotate freely within the casing of the generator. The friction between the brushes and the commutator is sufficient to cause the former, and with them the carrier, to be dragged around as the commutator revolves. The angular motion of the carrier is arrested by means of a stop. When the armature revolves in a right-hand direction, the brushes and carrier are rotated to the right and arrested by the stop in the correct position for commutation. When the armature revolves in a left-hand direction, the brushes and carrier are rotated to the left into a position also correct for commuta-

tion, but a position such that the polarity of the brushes would have been reversed, had not a reversal of rotation in the armature taken place simultaneously. But the rotation of the armature having been reversed, and also the position of the brushes, the actual polarity of the latter is preserved. It will be apparent that the angular motion of the brush carrier need be but 90° in a four-pole generator, such as is employed in this system.

The stop which arrests the motion of the carrier is removable, in order that, for inspection purposes and the renewal of brushes, the carrier may be turned completely around, and all the brushes and holders brought opposite the hand-holes in the generator casing.

As before mentioned, a single pair of brushes would suffice to take the current from the commutator, but by using four brushes, or two pairs, a shorter commutator is possible, a more symmetrical disposition of the brushes is secured, and the adequate friction between the brushes and the commutator is obtained, without undue pressure on a single brush. The brushes of similar polarity are connected together in the usual manner, while flexible cables, which are readily detachable, convey the current from the brushes to the stationary terminals of the generator. Thus it will be seen that in this system the preservation of the polarity of the brushes is secured mechanically, and yet no contacts, switch-blades or other devices, which break or interfere with the continuity of the circuit, are employed. The friction between the brushes and the commutator cannot be avoided, and in this system is utilized to advantage.

### The Automatic Generator Switch.

*Second.*—It is necessary to provide an automatic switch which will complete the circuit between the generator and the storage battery whenever the speed of the former, and consequently its voltage, is equal to or greater than that of the battery. On the other hand, this switch must likewise break that circuit whenever the voltage of the generator is less than that of the storage battery, by virtue of a reduced or zero speed. The object of this is apparent. The automatic generator switch opens and closes the circuit between the generator and the storage battery electrically, and is controlled directly by the generator voltage. It consists of a rectangular iron frame, which forms the magnetic circuit of the solenoid and supports the insulated contacts. Within the frame are two concentric coils, constituting the solenoid. They are made entirely separate, to facilitate con-

struction and repairs, and are held in place by a central tube. The inside, or lifting coil, is wound with fine wire, and is connected as a shunt across the terminals of the generator. The outside, or releasing coil, is wound with heavy wire and connected in series with the generator and storage battery. Within the central tube, and free to work in a vertical direction, is a soft-iron plunger, attached to and insulated from which is a laminated metal brush. When the generator develops its normal voltage of 64 volts, the fine wire or lifting coil will raise the plunger, thus causing the metal brush to make connection between two metallic contacts. If the generator voltage is increased, current will flow from the same through the contacts, brush, and series coil, and through the battery, the series coil being wound in such a direction that this current aids the shunt coil in holding up the plunger and brush, maintaining a better contact for increasing current. When, however, the voltage of the generator becomes less than that of the battery, current will flow from the battery in a reverse direction through the series coil and generator and oppose the action of the shunt coil. The weight of the plunger and brush is now sufficient to cause the opening of the switch by gravity. No springs are used to secure the adjustment. Adjustment is made by varying the length of the air-gap, and when once made is permanent. Carbon contacts, on which the final break takes place, protect the metallic parts against injury by arcing. See Fig. 7.

Upon the top of the iron frame of the automatic generator switch is mounted a triple contact, consisting of a three-part segmental socket and a conical plug fitting the same. The plug is raised and lowered by means of a tail-rod attached to the plunger of the switch. When the plunger is down and the generator switch open, the plug connects the three segments together. When the plunger and plug are raised by the lifting coil, the triple contact is broken. The plug is insulated from the tail-rod and a flexible conductor permanently connects the plug with an insulated terminal, also mounted on the iron frame. One lead of a resistance coil, located in the upper part of the switch-box, is connected to this insulated terminal, and the other lead is connected to the front segment of the triple contact. The negative lead of the generator is also connected to this segment. The leads of the lifting coil are connected, respectively, to the positive of the generator and the terminal to which the flexible conductor is attached. Thus it will be seen that when the plug

establishes the triple contact, it also short-circuits the resistance coil. When the plug is raised, it throws the resistance into series with the lifting coil.

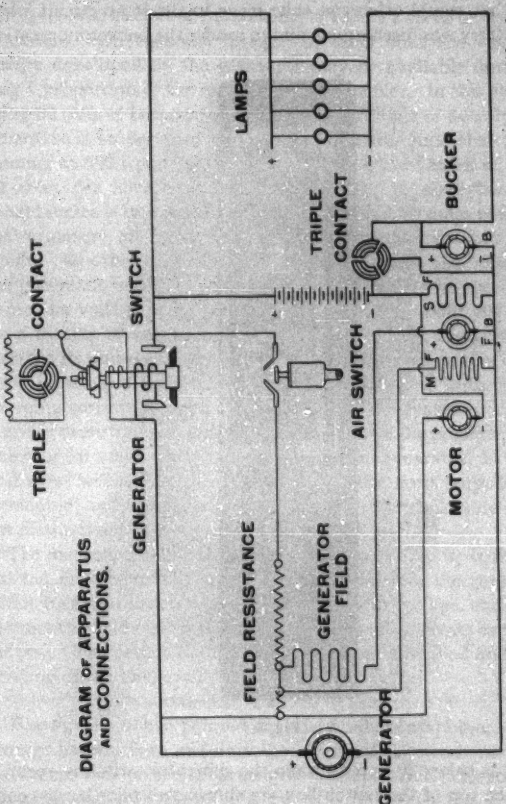



FIG. 7.—There is but one triple contact. It is shown in duplicate near the bucker to simplify the diagram and avoid a confusion of wires and crossings.

The resistance is thrown into series with the lifting coil: (1) To reduce the current and consequent heating in the coil, which would otherwise change its resistance and alter the adjustment of the switch; (2) to reduce the magnetizing effect of the coil, so

that less discharge current will be required in the releasing coil to open the switch, as above explained.

The function of the triple contact is to short-circuit the lamp bucker and series field, to be described later, thus avoiding the drop that would otherwise take place in the lamp circuit when the battery was discharging, and to render the bucker inoperative

Fig. 8.

at speeds below 20 m.p.h., when the generator switch is open.

At the top of the switch-box are shown two pilot-lamps, connected in series across the generator terminals. The lighting of these lamps affords a visual indication that the generator is in operation.

Fig. 8 represents the switch-box and switches complete. The cast-iron cover being removed, exposing the automatic generator

switch, with its triple contact and resistance coil. Below are seen the hand switch and air switch.

Regulating the Generator for Varying Train Speeds.

*Third.*—It is desirable to have the generator develop its normal voltage, equal to that of the battery, at as low a speed as possible, consistent with economic design, in order that the electrical energy developed by the generator may be available during as long a proportion of the car's travel as possible. In this system, using 32 cells of battery having a normal voltage of 64 volts, the generator is so designed and so geared to the axle that, when running at 500 r.p.m., corresponding with a train speed of about 20 miles per hour, it generates 64 volts. If, now, the train should increase its speed until it reached about 60 miles per hour, the armature of the generator would be making about 1,500 r.p.m. All other conditions remaining the same, the voltage of the generator would, of course, be proportional to its speed, and hence the voltage at its terminals would rise to about 192 volts. As a matter of fact it will be sufficient to have the generator increase its voltage to 80 volts at maximum speed, as this will be approximately 2.5 volts per cell, which is ample to force the full charging current through the battery. If the generator voltage is not in some way prevented from rising above the predetermined value of 80 volts, great overloading of the generator, batteries and wires will result. In fact, such increase must be positively prevented, and the provision of means therefor constitute one of the distinctive features of this system.

The method of regulation consists in generating, by independent means, a counter e.m.f. in the field circuit of the generator, which increases in proportion to its speed and voltage, and hence reduces the field current of the generator, and prevents excessive output. The details of this arrangement are described under the heading of the bucker and its operation.

Constant Lamp Voltage.

*Fourth.*—As above pointed out, the fundamental object of the storage battery is to maintain the supply of electrical energy for the lamps whenever the generator is inoperative. Hence it is customary to keep the lighting mains permanently connected to the terminals of the battery. (A hand switch placed in these mains serves to connect the lamps with the battery at will). The lamps are generally operated in parallel, and in this system are 60 or 65 volt lamps. When the battery, consisting of 32 cells, is freshly charged, its voltage is approximately 2 volts per cell,

giving a total voltage of 64 volts across the lamp mains. As the battery is discharged, this voltage will decrease, but should never be allowed to fall below 60 volts. On the other hand, it must never be allowed to exceed 64 volts.

If the train is brought to a speed such that the generator develops, say, 72 volts, sufficient to force about half the charging current through the battery, and the automatic generator switch be closed, the voltage at the terminals of the battery, and hence that impressed on the lamps, is 72 volts. This is an increase of 12½ per cent. in lamp voltage, an obviously excessive variation, while at 80 volts, which is necessary to force the full charging current through the battery, the variation in lamp voltage would be 25 per cent., which would probably be followed by destructive effects. In order that the voltage may remain constant at the lamps, irrespective of the rise of voltage at the battery terminals coincident with charging the same, it is necessary to resort to some form of artificial regulation.

In other words, a variable drop must be taken up in the lamp circuit, either by a variable resistance or rheostat, or by a variable counter e.m.f., to compensate for the rise of voltage at the terminals of the battery. But as the current in the lamp circuit may vary, due to a change in the number of lamps, a rheostat must change its resistance, not only to compensate for the rise in e.m.f. at the terminals of the battery, but also to meet the variation in the number of lamps in use. This requires a double variation of resistance, which, to be automatically performed, is very difficult. Hence a device having no resistance, but capable of developing a variable counter e.m.f., is far preferable; and a low-resistance armature, revolving at constant speed in a field which varies as the rise in e.m.f. at the terminals of the battery, is independent of the variation in the lamp current due to changes in the number of lamps, and constitutes such a device.

All the currents and e.m.f.'s developed in an axle-driven car lighting system are variables, and are functions of the train speed. There is, however, one rectilinear relation that exists among these quantities that can be utilized to produce a constant lamp voltage. It is an observed fact that the current that may be forced through a storage battery is almost directly proportional to the e.m.f. applied at its terminals, less the counter e.m.f. of the battery itself. In other words, the current forced through the battery (charging) is proportional to the increase in e.m.f. at its terminals. This is true over the greater range of the battery's

capacity. As the battery is charged, its counter e.m.f. rises slightly, and hence, when the battery is fully charged, the lamps will be brighter than if the battery were exhausted.

This relation between the charging current and the rise in voltage at the terminals of the battery is utilized in a manner extremely simple, theoretically perfect, and in practice so nearly so, that it requires the use of a good voltmeter to detect the changes in voltage on the lamps, no matter how many be in use or what the speed of the train may be.

### The "Bucker."

A separate auxiliary and self-contained machine which is called a "bucker," is bolted to the bottom of the car in any convenient place. This machine contains a revolving shaft on which are mounted two armature cores. One of these armatures with its commutator and field, constitutes a plain shunt motor which takes its power from the generator mains and whose sole function is to rotate the shaft. It is obvious that this motor runs only when the generator is in operation. The other armature has two windings and two commutators, and revolves in a field excited by the current flowing through the battery. This double-wound armature, with its two commutators and field, constitutes the "bucker" proper. The motor simply drives it. The winding connected in the lamp circuit is called the "lamp bucker," and the winding connected in the field circuit of the generator the "field bucker." The field of the "bucker" is referred to as the series field, that of the motor as the motor field.

Fig. 9 represents the "bucker" complete. As will be seen, it is entirely enclosed, and hence is dust and water-proof. It is impossible for any one to tamper with it, and it contains no delicate or complicated parts.

Fig. 10 shows the internal construction of the "bucker," it being similar to that of the generator, in being longitudinally divided in a horizontal plane.

The motor and "bucker" armatures are drum-wound for bipolar fields. They are built up of slotted annular punchings, and mounted, together with their commutators, on a sleeve which is fitted and keyed to the shaft. The construction is very similar, to, and possesses all the advantages of that employed in the generator armature previously described. There is no pulley or external mechanical connection to this machine.

The field is of the bipolar, ironclad type. Each armature core revolves between two salient pole-pieces, which are bolted into

the casing, and consist of a pole-shoe and core. Upon each core is placed a heavily taped and painted coil. The pole-pieces are placed in a vertical line, so that one pole and coil for each armature core is in the upper, and one in the lower part of the machine.

The brush-holders are mounted rigidly in the upper half of the machine. Their springs, fingers and cams are interchangeable with those of the generator. In taking off the bottom half of the casing, or in removing the armature, no wire connections need be disturbed, beyond disconnecting the two lower field leads, and the two leads connecting the fields.

The head-castings, containing the armature-shaft bearings, are secured to the casing by four bolts in each, thus permitting the

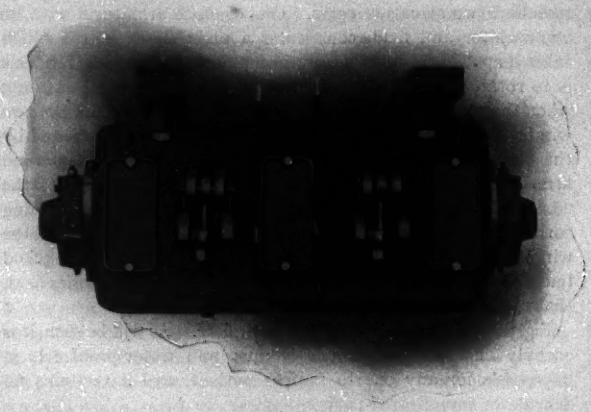


Fig. 9.

lowering of the bottom half of the casing with or without the armature. The armature is shown entirely removed, together with the head-castings and armature-shaft bearings. The separate parts of this machine are light enough to be easily handled, no jacks or lifting devices being necessary. By referring to the cuts, it will be seen that hand-hole covers are provided over each brush-holder, thus affording, by their removal, easy access to all the internal parts.

### Operation of the "Bucker."

When no current flows through the battery, none flows through the series field, and hence no e.m.f. is generated in the "bucker"; but

when current flows through this series field e.m.f's are generated in the "bucker," and in almost exact proportion to the strength of the field. (After the closing of the automatic generator switch, the motor runs at almost constant speed, its slight acceleration as the generator voltage rises from 64 to 80 volts, being an advantage, as it compensates for the drooping curve of magnetization in the series field.) See Fig. 7.

No current will flow through the series field under the following conditions:

1st. When the generator is inoperative, automatic generator switch open, and no lamps lighted, *e.g.*, car standing still in day time.

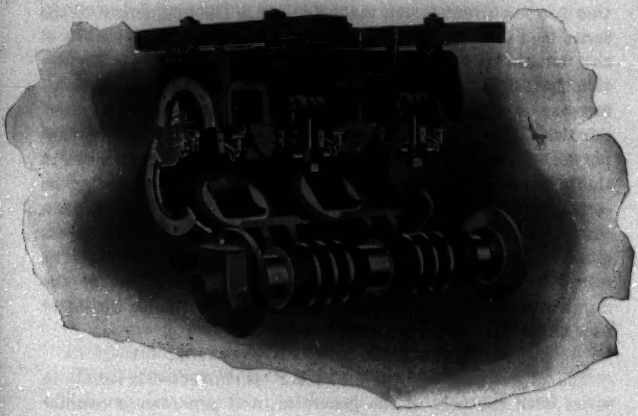


Fig. 10.

2d. When the generator is operative, automatic generator switch closed, no lamps lighted and the generator voltage equal to the battery voltage, *e.g.*, running 20 miles per hour in daytime.

3d. When the generator is operative, automatic generator switch closed, no lamps lighted and batteries discharging, carrying all or a portion of the lamp load, *e.g.*, running 20 to 25 miles per hour at night, lamps lighted. Current would, in this case, flow backward through the series field, as the battery is discharging, were it not prevented from so doing.

4th. When the generator is operative, automatic generator

switch closed, lamps lighted, and generator just carrying the lamp load, batteries neither charging nor discharging, *e.g.*, running 25 miles per hour at night, lamps lighted.

Under these conditions, no regulation of generator or lamps is necessary.

Only one condition obtains when regulation is necessary, and that is:

5th. When the generator speed and voltage have risen and the battery is being charged, *e.g.*, running above 25 miles per hour, day or night. Then the voltage at the lamps rises, and it must be kept constant, whether the lamps are lighted or not.

The voltage at the terminals of battery rises about in proportion to the current forced through them. The magnetism of the series field increases in proportion to this current. The e.m.f's of the "bucker" (its speed being nearly constant) increase in proportion to its field magnetism. Hence, the e. m. f's. of the "bucker" increase in proportion to the rise of e.m.f. at the battery terminals. If the winding connected in the lamp circuit be proportioned correctly, its e.m.f. can be made equal at all times to the increase of e.m.f. at the battery, and so if this winding be connected inversely in series with the lamps, it will produce a counter e.m.f. in the lamp circuit always equal to the excess e.m.f. necessary to impress on the batteries to charge them. The result will be a constant lamp voltage, independent of the number of lamps in use, or the speed of the train, since the latter now affects the charging current only.

### Regulation of the Generator.

The other winding of the "bucker" is connected inversely in series with the field of the generator, and generates a counter e.m.f. which weakens the field of the latter to such a degree that the e. m. f. of the generator is just sufficient at the maximum train speed to force the maximum predetermined current through the battery and series field. The regulation tends to maintain constant current through the battery and series field at a given train speed. The lamp load is carried by the generator precisely as in the case of a constant potential machine and does not affect the charging current flowing through the battery.

Since the "bucker" receives or absorbs energy from the lamp circuit and the field circuit of the generator, such energy is transformed into mechanical power and tends to revolve the shaft and thus relieve the motor of that work. In fact, when the apparatus is fully loaded, the motor becomes a generator and puts back

into the system about 60 per cent. of the energy consumed by the "bucker" in effecting regulation.

Under (3) no regulation for holding down the lamp voltage or generator output is necessary, but since, under such conditions, the battery would discharge and current would flow from the battery through the lamps, "lamp bucker," and backward through the series field, the polarity of the "bucker" would be reversed, and the latter would become a booster and tend to raise the lamp voltage and increase the generator output by strengthening the field of same. This tendency of the "bucker" to "boost" when the battery discharges through the series-field, while the generator switch is closed and the triple contact open, as already explained, is prevented by causing the current which flows from the generator through the motor to return through the series field in a direction opposite to that of the battery current discharging through the lamps and series-field. This motor current increases with the tendency of the "bucker" to "boost", which tendency is proportional to the lamp load at this time, for the more heavily the "bucker" (now a booster) is loaded the greater the motor current required to drive it. As these two currents cannot flow through the same field at the same time in opposite directions, their resultant, which in this case is their difference, is the current which actually flows; and such resultant can, by proper design, be made approximately zero; or, at least, the tendency to "boost" can be practically eliminated.

### Air-Operated Field Switch.

In addition to the difficulties to be overcome to render the electrical operation of the system perfect, there is one other point which requires attention, although not absolutely vital. For the sake of simplicity, a self-excited generator is usually employed, although it is not uncommon to separately excite the field of the generator by means of current from the storage battery. If such current be used to excite said field, provision must be made to discontinue it after the car goes out of service; otherwise, a useless discharge of the battery will take place. It is desirable to provide some form of separate excitation, as the generator may fail to excite or "pick up" at the proper speed through loss of residual magnetism, imperfect contact of brushes, etc.

In this system, the generator remains connected as a self-exciting machine, and eventually furnishes the strong current in its field required to produce 64 volts at the low speed of 20 miles per hour. Separate excitation for the field of the generator, and

also for the field of the motor which drives the "bucker," thus enabling the motor to start readily, is supplied by means of current from the storage battery, which current is limited to a small value by the field resistance. The circuit from the storage battery through the field resistance is controlled by an automatic device called the air switch. This consists of a cylinder, to the lower end of which a branch from the signal pipe of the car is connected. An ordinary gas-cock, included in this branch pipe, serves to cut off the supply of air, so that the cylinder may be opened or disconnected without venting the signal line. Within the cylinder is a cup-shaped piston, to which a rod is attached. The latter extends through the cylinder head and carries an insulated contact disk. The piston is held in its normal position by means of a helical spring surrounding the piston rod, and engaging with the inside of the cup-shaped piston and the under side of the cylinder head. When the piston is forced upward by air pressure, the rim of the cup is pressed against the gasket, which packs the cylinder head, thus sealing the cylinder and preventing escape of air. This construction permits the use of a loose-fitting piston, which ensures freedom from possible sticking. At the same time the contact disk on the piston-rod establishes connection between the two spring contacts mounted upon and insulated from the cylinder head, and which are secured by the same bolts that hold the latter in place. The heads of these bolts form binding-posts for the reception of the circuit wires. A bonnet or hood protects the contact parts. See Fig. 8.

When the locomotive is coupled to the train and the hose couplings are connected, pressure is at once applied to the air-switch and the circuit is closed. When the locomotive is uncoupled, the pressure in the signal pipe rapidly falls, opening the air-switch immediately, or within a few minutes. Reduction of pressure, caused by giving signals, does not open the switch, and even if it did, no harm would result, as the switch may be opened with impunity as soon as the generator has developed a stable voltage of about 15 volts. When the automatic generator switch closes, it short-circuits the air-switch, in addition to its other functions. After the disconnection of the locomotive, the conductors' valve may be used to open all the switches on a train simultaneously, in case the pressure in the signal pipe is retained. The leaks in the hose couplings are sufficient to cause a rapid falling in pressure and a quick opening of the air-switch

*A paper read at the 173d Meeting of the American Institute of Electrical Engineers, New York, February 27th, 1903.*

# AXLE-LIGHTING.

BY ELMER A. SPERRY.

A historical view of electric train lighting; a statement of some of the problems encountered; a criticism of some of the methods employed in solving these problems, and an announcement concerning a new system of axle-lighting.

The persistence of methods casually considered as "good enough" is well illustrated by a review of the small advances of the past decade in car lighting. When the series of trains known as The Pennsylvania Limited, had then been electrically illuminated throughout for more than five years, an author of ability started his excellent work by denominating this subject a "burning question." This was twelve years ago. Oils and naphtha and their products was the burden of his message, and yet, to-day, we are confronted by all too frequent reminders that it has not, as yet, emerged from this class.

That the confines of this "burning question" lamentably is not limited to illumination, is illustrated by the periodic firing of solidly steam-heated trains in state of wreck.

Oil, gas, carbonated-air gas generators and acetylene are employed, some very extensively; some, if not most of them, combustible and inflammable to a superlative degree and necessarily in close proximity to combustible linings and trimmings.

The mass of work that has been done as exhibited by the elaborate details which have been perfected in many of these systems, emphasizes the importance of a perfect system of car and train illumination.

Electricity has been proposed from the very first. When the early platinum filament gave forth its prophecy, its adaptability

to car lighting was at once seen, and a great future was predicted for this form of illumination for trains.

Among its points of superiority, should not be overlooked the fact that it is cleaner, more pleasing than any other, and lends itself more readily to decorative effects. It can be divided into smaller units than any other and can thus be distributed and placed in more advantageous positions; its familiar use as reading lights, or berth lights, serves to illustrate this point. Also the heat emitted is negligible. It is absolutely unaffected by draughts; it maintains its original candle-power better on the whole than any other light, and is less dependent for its existence on the faithful care of the trainmen. Its safety is beyond question. From it no oil can drip, no odor or smoke can be emitted, and there is entire absence of odor in the stations. Many important stations are rendered almost unbearable by the pungent and poisonous odor of compressed gas.

Electrical car lighting in America will attain its majority within the present year. In August, 1882, the Pennsylvania Railroad Company electrically equipped car No. 397 with Faure Accumulators imported from France for the purpose. Not only is this the earliest application of electricity to car lighting in this country, but in fact one of the earliest in the world. Again, it was this same enterprising road that promoted the first installation of the solid electrically illuminated trains or series of trains, the Pennsylvania Limited, between New York and Chicago. These equipments were installed in the middle eighties and are still in continuous service; all are direct-connected sets in the baggage compartment, supplying the lamps, together with batteries under each car.

Meanwhile, English railways were active in the same line, their first installations being axle-driven. The London, Brighton and South Coast Railway, in 1883, put on its first axle-driven equipment, which furnished a few lamps throughout the entire train, not many more than was supplied to a single Pullman car in this country. In 1885 the Mechanical Superintendent of this road, Mr. Stroudley, described this system in detail before the Institution of Civil Engineers in London.

This was quickly followed by the Great Northern and the Midland roads, each of which in 1886 developed similar equipment, one using the old Brush dynamo, both dynamo and batteries in the "guard's van," similar in this particular to the Brighton and South Coast road. The difficulty of leaving the cars in total darkness on breaking up the train was later obviated

in the Midland equipment by distributing the batteries under each car, as was practised in the Pullman equipment in this country. Many of these early installations are still in service.

The writer has recently had opportunity personally to inspect some of the oldest of these equipments, and can testify to their marvelous state of preservation, especially considering the service they have seen. It should be stated in passing that these old equipments are of extreme value in throwing light upon the one great unknown factor in ascertaining the cost of operation; namely, deterioration. The experience of these roads allows us to establish a sinking fund which it is believed can be depended upon to take care of this portion of the cost of operation the other factor being more easily determined.

In passing from the old to the new, it is interesting to note the transformation which we have all noted in the new Manhattan Elevated cars in New York City, which have been electrically equipped. Nothing could better illustrate the comparative merits in point both of candle power and practical "visual units," and of distribution, than the marked contrast between this system and that of the old steam-hauled trains, both of which recently could have been seen constantly passing in the busy hours.

In calculating the electrical power consumption of a car illuminated in a highly satisfactory manner, one is struck with the smallness of the amount required for maintaining the lights. This, when properly adjusted, is found to sink into insignificance as compared with the power required to haul the train, or the particular portion of such power represented in the individual car.

In our modern service the locomotive represents, really, a power station of no mean dimensions, developing, as it does, from one thousand to fourteen hundred horse power and even, at times, a power in excess of this amount. The illumination of the entire train represents not far from one per cent. of this, and with a proper combination of generating units and accumulators, considerably less. In view of modern practice, in other lines, it is found that even with a light battery a generator may be employed during a part only of the day period and thus reduce considerably the maximum power required at any one time, say at the time of the heaviest load. Thus, as a part of every train, there is at hand a power station of large dimensions from which should be drawn the insignificant amount of energy required for illuminating purposes, if the equipment is properly suited to the conditions.

A perfect system requires that every car shall be entirely independent of every other, and shall maintain its lights perfectly after the train is broken up. Many efforts have been made to perfect devices to accomplish this purpose, and they operate more or less successfully. It was my privilege to be called upon recently to investigate the systems that have been offered, with a view to ascertaining the practicability, the reliability, the closeness of regulation and other features of their operation. Much ingenuity and some good engineering is displayed in and about these systems. A criticism might be made that some of the engineering has evidently been done by the electrician rather than by the trained engineer. Some systems employ belt drives as a means of mechanically coupling the generator to the axle. Some of our present fast trains that are thus equipped have come through repeatedly with every belt on the train gone. Again, in some of these equipments, the generator is mounted on the car body with no means of coördinating its lines with the constantly changing alignment of the axle within the swivelling truck. Some are mounted upon the trucks themselves, but so hung that the truck-springs over the axle boxes are required to be re-inforced upon this end of the truck, owing to the overloaded condition thus imposed. In one of these equipments hand regulation is in a large measure depended upon, causing the reliability of the system to turn on the faithfulness and intelligence of the trainmen.

It is certain that the system of the future must be one that is thoroughly automatic throughout, especially in view of the modern trend and perfection of electrical and mechanical appliances. Systems employing slip frictional driving devices for regulation, are open to serious objection in point of power absorption. This problem, at best, is a difficult one. The generator is asked to take on its load at say twenty miles an hour and to continue while the car often reaches a speed of eighty miles per hour. There are instances where the generator is expected to assume its load at even lower speeds, as at fifteen or seventeen miles per hour. This gives a speed variation of four or five to one. It is manifestly undesirable to operate a generator that is large enough to carry its entire load say at 500 r.p.m. at a speed five times as great. Not only does the serious matter of commutation arise, but also a complication of other electric difficulties. Mechanically, it is difficult to build and guarantee a machine under these conditions. Thus it is that slipping

friction devices have been suggested that they may intervene and save the generator. The peripheral velocity in this case, however, has increased four or five times while constantly delivering the large torque strain that was required at the *lowest* speed limit. The other three-fourths or four-fifths of the power, which is positively developed and delivered under these conditions, passes into heat which has to be dissipated, often proving a serious problem, burning and destroying the belts, and other frictional devices employed.

Such waste as this should certainly be avoided, notwithstanding the large capacity of the source of supply. Again, other systems introduce commutating difficulties at the higher speeds. A generator required to assume its load at say sixteen miles per hour must commutate the same load at four and one-half to five times this speed. An increase of heating results from the increase in speed of rotation, arising from hysteresis and other core losses in the armature.

A system has been devised whereby the excess of current developed is neutralized by an elaborate mechanism, which is required to be maintained and operated constantly from the battery circuit and requiring power whenever the equipment is in service. It would seem, from an engineering standpoint, that it would be far better not to call upon the generator for either excessive currents requiring dissipation or upon the car and axle for any more power than is actually required for economically handling the service proposed, and further, not even upon the generator for more speed of rotation than is actually necessary to maintain its load or potentials perfectly constant under the varying conditions.

Another important feature, and one which must always be reckoned with primarily in the car lighting system is perfect and constant control. Here a number of factors are encountered which must be so dealt with as to overcome entirely other influences. Among these are the reversal in direction of rotation, the irregularity and spasmodic magnitude of the variation in speed, the variation in the charging and the discharging e.m.f. of the battery, the jar and tremor of the car or truck on which the apparatus is mounted, and the variation in the load or number of lamps in the circuit.

All that have ridden on cars with axle-driven equipments have noted to what degree this matter of regulation is carried out. Fairly good regulation is not good enough for the lighting of com-

partments under constant use and criticism of the changing public. A dimming light will disgust and a brightening light will surprise a passenger, who can always be counted upon as overhasty in judgment and hypercritical. It is perfectly apparent that to compass perfect regulation ponderable masses must be employed and controlled with great precision to keep pace with the erratic changes in speed. To accomplish this it is apparent that the control of such devices and masses cannot be attempted directly by the slight changes in the voltage at command, though they must be perfectly responsive to such changes. Devices that cannot be considered as delicate or be criticised as being other than practical, and which operate within one-half of one per cent. have been found efficient and reliable for control under these conditions.

Announcement is hereby made of the design of a new system of axle lighting. With these regulating devices we have now had six or eight years of experience in continuous and heavy service and the features of its operation have become familiar and its reliability established. The sensitive moving part may be statically balanced, freeing them entirely from any response to the vibrations, jerk and jar of the car and rendering them entirely independent thereof. This device may be relied upon thoroughly to regulate not only the potential as delivered to the lighting circuit under varying conditions of load and battery pressure, but also to handle the generator under all possible conditions of speed variation, reversal and change of load. Furthermore, it has been found that a number of valuable features, having an important bearing on this particular subject, and which have never before been introduced as factors, may be employed with perfect success with this system of control and regulation. Not the least of these is a *constant speed generator* the use of which cuts down the torque delivery from the axle and thus the power absorbed from the axle, in exact accord with the demand for electricity at the time from the generator. When the battery is nearly charged, this current should be largely reduced, and its e.m.f. slightly and gradually increased. Any device which will take from a moving train only the power that is at that instant required to be developed and as the demand falls off will release all overplus of power to the train, is certainly desirable, if not positively necessary to the success of the coming train-lighting equipment. Especially is this true in view of the fact that by this device a large amount of power now wasted is

not only saved but left available for traction purposes to the locomotive, which is already taxed to its utmost to meet the modern demand for high speeds of heavy equipment. Moreover, by this system the weight of battery and generators may be reduced, and the whole system rendered simple in the extreme. Nothing is found necessary to the installation inside the car except the ordinary switch-panel for controlling the lamps of the car. In some instances, such as private and wild-cat cars, it might be advisable to install a voltmeter and ammeter or a combined single instrument which has been designed. Again, in this particular style of equipment, there has been included apparatus designed primarily to reinforce the battery when such a car is required to stand idle on a siding for a considerable length of time. This equipment allows the batteries to be charged from the ordinary 110 volt a.c. as well as d.c. service, Such service is to be had in almost any station whenever the necessity arises, thus furnishing an element of the system not met in equipment heretofore offered. In this instance, the constant speed machine does not require to take on its load at lower than its normal speed. Therefore, it is of minimum weight and size. The generator is suspended interior to the truck and no belts or other than toothed wheels are employed in driving. All parts are housed in dust-proof cases and automatically oiled, and designed to operate for long periods without attention. The generator itself is sealed and can work in snow, wet or dry with equal reliability. The heating factor is low and radiation ample to keep the temperature well within prescribed limits. The air-wash still further reduces the liability to overheat.

The whole question of car lighting turns on practicability,—can the system be made reliable in independent units and at the same time can it compete in point of cost per unit of light? It is true that it does not need to equal the other systems in point of cost per light-unit, owing to the superiority of distribution and its many apparent advantages. It is, therefore, with considerable gratification that the writer is prepared to state that upon this all-important question of cost this system, as a matter of fact, *can compete successfully*.

Taking the items of deterioration and up-keep, as developed by the plants which have been longest in operation and including interest and all essential factors, it can be stated that a *candle-power-hour* can be produced for about 68 per cent. of the cost of

compressed gas, and that such gas, as now used, costs in the neighborhood of 46 per cent. more than an equal illumination in candle-power by the present axle-driven equipment. When calculated in visual units, which includes the distribution factor, compressed gas is in excess of 50 per cent. more expensive than electric illumination, a result upon which it is believed the electrical fraternity should be congratulated, and which should open up a large field for the use of electric apparatus.

*A paper read at the 173d Meeting of the American Institute of Electrical Engineers, New York, February 27th, 1903.*

# AN AXLE-LIGHT SYSTEM OF TRAIN LIGHTING.

BY ARTHUR J. FARNSWORTH.

Reasons why axle-systems of electric train lighting have theoretical possibilities of meeting the exacting requirements of the problem better than other systems. A description of an axle-lighting system and its operation.

It is now generally admitted that electricity is destined to be as universally adopted for the lighting of passenger cars on steam railroads as it has been for the interior illumination of buildings. In addition to the well-known advantages it offers as a source of artificial illumination, it is the only light that can be located satisfactorily in any other place than the deck of railway cars, owing to their peculiar construction, and above all, there is the vital argument of safety.

The problem of electrically lighting steam railroad cars naturally presents greater difficulties than are met with in stationary lighting installations. In addition to furnishing the current and maintaining the pressure within satisfactory limits, the system must assure a reliable and continuous lighting service; permit of the cars being assigned to any run on their own or foreign roads; have a negligible effect upon the hauling capacity of the locomotive and compare favorably as to cost of installation and operation with other systems.

For the generation of electricity for train lighting it is possible to make use of power developed in a stationary plant and stored in electric storage batteries; to utilize small independent steam motors, operated by live steam from the locomotive; or to generate the power directly and economically in the large

locomotive cylinders and transmit it through the car axles of the train.

The first two of these can only be made use of in special service confined to certain territory and runs. It is the axle system alone that has an unlimited field of operation. This generating car unit system, therefore, possesses an inherent advantage that should bring it into universal use, provided the apparatus is constructed to fulfil the severe duty imposed upon it. Each car thus equipped contains its own complete electric lighting plant with economical power available and independent of any service and all other equipment.

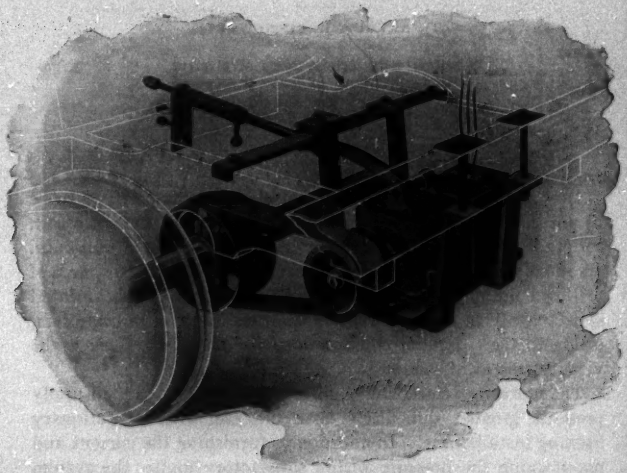


FIG. 1.

The essential requirements of an axle electric lighting system are reliability, automatic operation, close control of voltage at all times, negligible drag upon the locomotive and small total cost of operation.

There are several axle electric lighting systems in use. The main differences between these are in the transmission of power from the revolving car axle to the generator; the means employed to maintain a constant voltage at the lamps at all speeds, and the design of the apparatus, so as to make it as automatic as possible and at the same time so simple that it can be readily understood and taken care of by cheap labor.

The problem of transmitting the power is difficult, for several reasons. The plan of installing the generator in a manner similar to that in which street car motors are mounted is not to-day considered feasible. Railway mechanical officials have adopted the taper axle almost universally, and will not consider any proposition to turn thereon the necessary straight bearings for the generator suspension. Consequently the dynamo must be located independent of the axle, and the drive must provide for a vertical and lateral motion of the latter and a variable distance between centers.

It is also absolutely essential that the drive shall possess the utmost simplicity and be accessible, so that truckmen can easily remove and replace it when changing car wheels. Simple as the matter at first appears, this requirement has proved to be a serious obstacle.

For the transmission of power, a large number of devices have been tried, including gears, sprocket chains, friction pulleys and belts. At the present time belts appear to be in greatest favor, and are used on probably more than 90 per cent. of existing axle lighting devices throughout the world to-day. They have a certain elasticity that is lacking with gears, and vibration and shock are not transmitted by them to any great extent. They do not require lubrication, and if the belt drive is properly designed will run a long time and pull the load.

The second difficult problem is the satisfactory regulation of voltage. As the speed of a railway train is constantly changing, it is necessary to employ means to counteract the tendency to voltage variation. For this purpose various forms of differential winding have been used with some success; and a crude method of accomplishing the result very imperfectly is to depend upon the belt slipping when an abnormal load has been reached.

The principle upon which the system here described is based, is to control the output of the generator and keep it constant by varying the resistance in the field circuit to correspond to the train speed. The regulating mechanism which accomplishes this is thrown into action whenever the generator current varies from normal. It is designed: first, to maintain a constant output of the generator at all train speeds above the "critical speed," or the speed at which it becomes operative; and, secondly, to maintain a constant voltage at the lamps, whether they are being fed from the battery alone, or whether they are connected in multiple with

both the generator and battery at speeds above the critical speed.

The equipment of this system consists essentially of a generator installed upon the truck of the car and driven from the axle by means of a belt; a regulator installed in any convenient location in the interior of the car, and a storage battery hung in a suitable box from the car body.

The generator (Fig. 2) is a bi-polar, laminated field, shunt-wound machine. It is ironclad and provided with self-oiling and self-aligning bearings. It is completely enclosed with dust-tight covers which may be easily removed for purposes of inspection. It is installed on suspension-irons hung on the truck

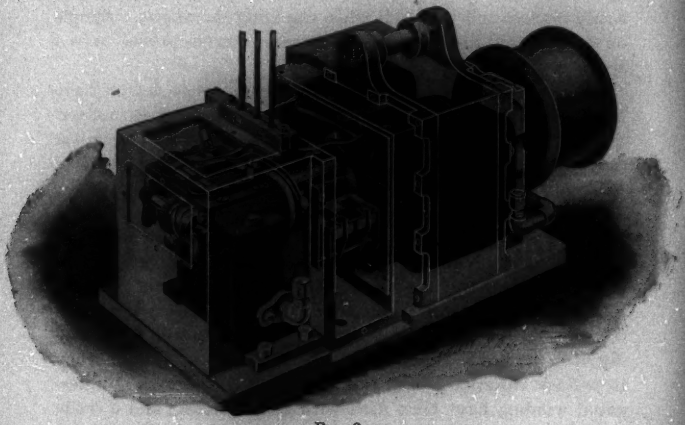


FIG. 2.

timbers, one method being shown in Fig. 1, and is pivoted parallel with the axle, on adjustable pivot-shoes to provide for perfect alignment. A tension rod and spring maintain the proper tension on the belt, the machine being free to swing on its pivot so that any movement of the axle from its normal position will not affect the belt tension. The generator is provided with a flanged crown pulley and on the axle is clamped a flat-face flanged driving pulley, the two being belted together with a rubber belt. The armature shaft carries a worm operating a gear and cylindrical cam, which throws a switch when the direction of rotation of the armature is reversed. The polarity of the generator is thus maintained correct, independent of the direction in which the train is moving.

Carbon brushes are used and the design and proportions are such that if the machine is maintained in good condition it will run cool and sparkless under any ordinary conditions of service. The laminated fields contain a few sheets of hard steel, which retain sufficient residual magnetism to cause the generator to build up its voltage promptly at low speeds. The machine is constructed throughout to meet the severe requirements of railway service and to operate successfully with a minimum amount of care and attention.

The regulator (Fig. 3) contains a solenoid with spring-balanced plunger to control its operation; the generator field rheostat; a small electric motor connected by means of worm gear and ratchet mechanism to the rheostat to operate it; an automatic switch for automatically switching the generator in multiple with the lamps and battery at the critical speed when the speed is rising, and for cutting it out at the same speed when the speed is falling; and a variable lamp resistance operated by the same mechanism that works the field rheostat.

All the operations of the regulator are automatic. The motor is provided with self-oiling bearings, and requires only occasional attention. Re-adjustment of the regulator, when it is once properly set, is seldom necessary.

The battery used is admirably adapted for this class of service, requiring little attention and not subject to rapid depreciation. It is usually proportioned to provide for about ten hours' continuous burning of all the lamps, although in the case of cars subject to long lay-overs this capacity may be increased. Current for the lamps is thus insured under all ordinary circumstances arising in practice.

The automatic switch or cut-out has four bobbins, as shown in the upper right hand corner of Fig. 3. The lower two are wound with fine wire, and the upper two have a winding of heavy wire to carry the main generator current. The lower bobbins always remain connected across the generator terminals through the field fuse and main fuse in series, as shown on the wiring diagram at F, Fig. 4.

As the train accelerates and the generator voltage builds up, current flows through the fine wire winding of the lower coils of the automatic switch and their cores become magnetized in proportion to the rise in voltage. When the voltage of the generator reaches the point where it about equals that of the battery, the magnetic pull of these coils overcomes their weight and that of the lever and resist-

ance of the opposing spring, and the switch goes in and connects the generator in multiple with the battery and lamps. The main dynamo circuit is then complete from the generator, G, Fig. 4, and fuse, F, through the solenoid, S; through the two coarse wire coils of the "automatic switch," C (in multiple), contacts HJ, through the battery, B, and back to the negative terminal of the generator, G. If the lamp circuits are turned on the current divides part going to the battery and part through the lamp resistance, E, to the lamps, L. As the speed of the train increases above the critical speed, *i.e.* the speed where the cut-out goes in, the generator

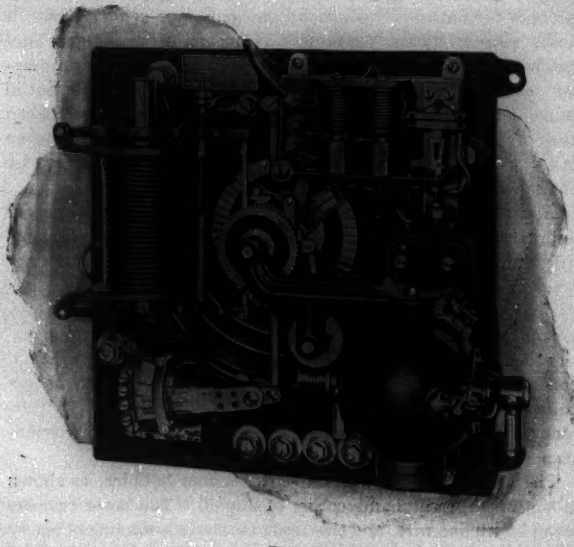


FIG. 3.

current increases in proportion until it reaches the point where the magnetic pull on the solenoid core balances the pull of its opposing spring.

Any further increase of train speed, tending to increase the current generated, will cause the solenoid spring to be overbalanced, throw into gear the ratchet mechanism and move the generator field rheostat arm through one or more contacts until the current is cut down to the proper amount and the solenoid plunger is again in equilibrium. A still further increase of speed

will act in the same manner. A decrease of speed will cause the mechanism to act in a similar manner and cut out resistance from the field circuit of the generator. The generator current is thus maintained nearly constant at all speeds above the critical speed.

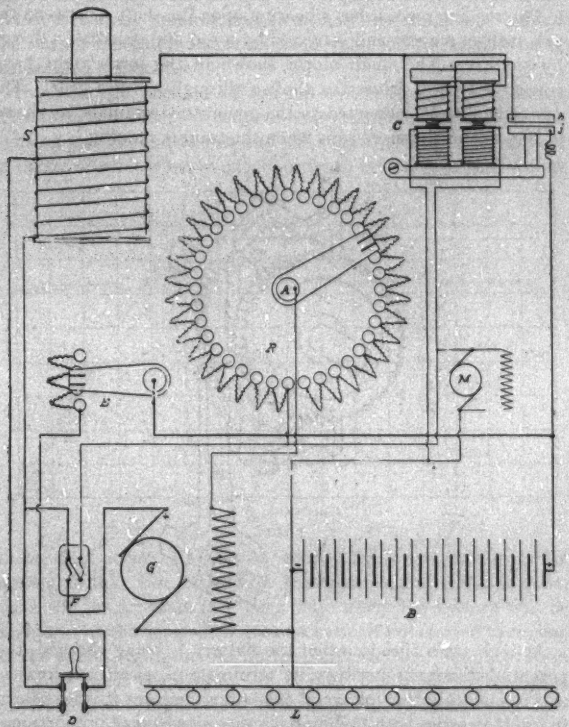
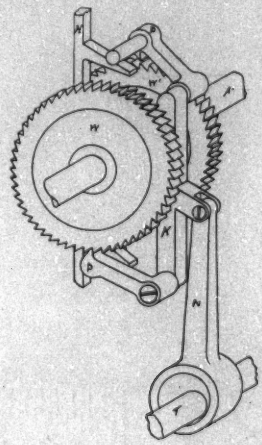



FIG. 4.

Details of the ratchet mechanism are shown in Fig. 5, where A is the generator field rheostat shaft, upon which are secured the ratchet wheels W and W′. The vertical link H, a portion of which is shown, is worked directly by the main solenoid plunger (see Fig. 3). It is provided with two arms upon which slide

bosses cast upon the two pawls. When the dynamo is generating the proper current the position of H is such that neither pawl can engage its wheel. Any displacement of H up or down due to a variation of the dynamo current will throw into gear the upper or lower pawl, as the case may be. It is obviously impossible for both pawls to be thrown into gear at the same time.

The rocking piece K has a bearing upon the shaft A between the two ratchet wheels, and is moved by a rod and eccentric N driven by shaft T. The small motor shown in the lower right hand corner of Fig. 3, drives the shaft T through a worm gear. The motor is always connected to the generator terminals, as shown in Fig. 4, and therefore runs when the train is running.



At high train speeds, when the battery is being charged, the potential difference between its terminals necessarily increases; and to maintain the voltage at the lamps constant it is necessary to insert in series with the lamp circuits a resistance proportional to the increase in voltage of the battery above its normal discharge voltage. There is, therefore, provided a variable resistance shown in the lower left hand corner of Fig. 3. By means of a reach rod engaging through a roller, a circular cam upon the rheostat shaft A (not shown in the cuts) resistance begins to be thrown in the lamp circuits at the same time it is first thrown in the generator field.

The regulator is adjusted in each case for the average run of the car, so that it shall maintain the generator output sufficient to keep the battery charged without excessively overcharging it. As will be noticed on the wiring diagram, Fig. 4, the series solenoid may be partially short-circuited by means of the same switch that turns on the lamp circuits. In this manner, during the daylight run of the car the generator output is maintained at a small amount, but as soon as the lamps are lighted the output instantly increases, each value of the output being maintained constant.

To make the solenoid adjustment it is necessary to determine the average number of ampere-hours required per day for the lighting service, and to put into the system a certain percentage in excess of what is taken out, in order to take care of the various

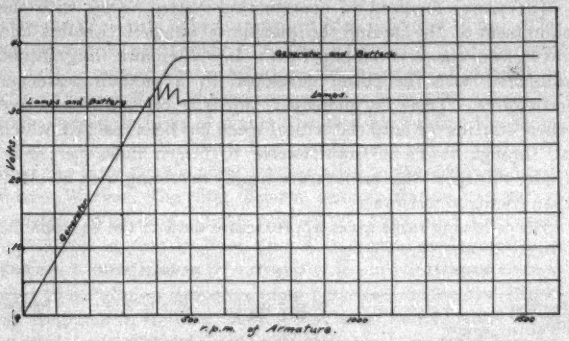



FIG. 6.

losses that occur. It is wise, too, to figure generously in this respect to take care of possible emergencies, and if this is done, there will be a certain time each day when the battery will be slightly overcharging. This does no harm, if not carried to excess, as the overcharging breaks up the sulphate that tends to form at times upon the plates. It is only continual overcharging or charging at a high rate that is injurious, and neither of these things can happen with the equipment under discussion, if the apparatus is properly adjusted in the first place and not changed thereafter, except to provide for new conditions in the run or service.

The curves shown in Fig. 6 represent a shop test of this apparatus. There was, however, no effort made to make the adjust-

ments with unusual care and the battery at the time was pretty well discharged. The jumps in the lamp curve just after the generator has "cut in," are due to the lamp resistance being inserted. This effect could, of course, be reduced by splitting up the resistance into a larger number of steps. The variation in the light, however, is very slight, and ordinarily is not complained of.

Except for those few moments when the lamp resistance is being inserted the voltage variation at the lamps can easily be kept within 4 or 5 per cent., which is very close for this class of service. The close regulation of voltage is also demonstrated by the fact that the lamps ordinarily furnished with these equipments are of very high efficiency, consuming only two and one-half watts per candle-power.

The power required to operate this system varies with the equipment of the car and the number of lamps it contains and varies from one to two h.p. per car. It is, therefore, insignificant compared with the power developed by a modern passenger locomotive. There is, moreover, no drag on the locomotive when starting, or until the critical speed has been reached, which on through trains is from twelve to fifteen miles per hour. Under this speed the armature is simply revolving with no other than frictional resistance.

The following table gives approximate data of the equipment:

| EQUIPMENT. | CAPACITY. | SPACE OCCUPIED. | WEIGHT. |
|---|---|---|---|
| Generator | 75 8 c.p. lamps. | 33″ x 14″ x 13″ | 500 lbs. |
| Regulator | 75 8 c.p. lamps. | 17″ x 19″ x 9½″ | 75 " |
| 9 E Battery (Single) 24 lamps for 10 hours | 160 amp. hours. | 54″ x 20″ x 21″ | 865 " |
| 13 E Battery (Single) 36 lamps for 10 hours | 240 amp. hours. | 72″ x 20″ x 22″ | 1280 " |
| 9 E Battery (Double) 48 lamps for 10 hours | 320 amp. hours. | 85″ x 20″ x 27″ | 1730 " |
| 13 E Battery (Double) 72 lamps for 10 hours | 480 amp. hours. | 91″ x 20″ x 36″ | 2560 " |

*A paper read at the 173d Meeting of the American Institute of Electrical Engineers, New York, February 27th, 1908.*

# SOME OF THE PROBLEMS OF ELECTRIC TRAIN LIGHTING.

BY GEO. D. SHEPARDSON.

The use of electric light in transportation is no new thing. The first commercial plant sold by the Edison Company to be operated by outside parties was installed on the steamship Columbia in 1879 at Chester, Pa., and began operation in May, 1880. Another of the very early isolated plants was used for lighting the shops of the Manhattan Railroad, beginning in the fall of 1881. At about the same time a plant was installed in the Baldwin Locomotive Works. The first Edison central station started at Appleton, Wisconsin, about August 20, 1882, and the larger Pearl Street station in New York City started on September 4, 1882, were antedated nearly a year by the application of electric lights to a Pullman sleeper running between London and Brighton, England, in October, 1881. The latter had 12 small lamps supplied from 32 Faure cells. This was so successful that by December of the same year the whole train of eight cars was equipped with 29 Edison lamps of 9 to 10 candle-power, supplied from 80 cells of storage battery. An electric headlight operated by steam engine and dynamo mounted on the locomotive was used on the Kronprinz-Rudolf-Bahn on the night of March 19-20, 1881, and was followed in December of the same year by others in France. As early as 1879, Hinkefus and Wesel took out a German patent on a train lighting system in which a dynamo driven from the car axle operated incandescent lamps. Even before the Pearl Street station was in operation, the Pennsylvania Railroad began experimenting with incandescent lamps operated by storage batteries under the cars, importing Faure cells from

France in the spring of 1882, and installing them on a car in August of the same year. Although this experiment was not a conspicuous success, the company renewed its experiments in 1884, and in the following year began the regular operation of electric lighted cars. From this beginning, the company has continually increased its electrical equipment, until recently it has adopted the electric light as standard for all passenger service.

From the standpoint of the railroad men, the requirements for a system for train lighting are reliability, safety, freedom from features objectionable to passengers, cheapness in first cost and low cost of maintenance. All of these requirements are matters of degree. For absolute safety from fire and explosion, nothing can equal the incandescent electric lamp when installed and maintained in accordance with established practice. The voltages used on trains are invariably low and well within the limits of danger or even discomfort to persons who might by some unusual way come into contact with the conductors. That the service may be made reliable is attested by the fact that many cars provided with no auxiliary light whatever are in use on such roads as the Chicago, Milwaukee and St. Paul, which has been using electric lights since 1890. The Pennsylvania road, which was the first in America to experiment with electric lights for car lighting, is now equipping all of its cars west of Pittsburg with electric lights, and is reported to be throwing out all auxiliary lights. The incandescent electric light is free from the smoke, smell, vitiation of atmosphere and the possibility of fire and explosion common to all competitors, and it yields such a moderate amount of heat that it may be said to be absolutely free from features objectionable to passengers, except those of occasional dimness or of infrequent unsteadiness. Furthermore, the advantage of adaptability to local and decorative lighting, such as dining table or berth lighting, and the possibility of advertising tail transparencies, the convenience of electric fan ventilation and of electric heaters, make the electrically equipped train the choice of fastidious travelers. In the matter of cost, electric lights compare favorably with others when quality and quantity are considered.

The application of electricity to train lighting is now over twenty-one years old, and may be said to have reached its maturity. It has not ceased to develop and improve, but it has reached the age of responsibility and reliability. Like other adults, it still meets problems to be solved and looks forward to a bright future.

All of the various systems of car lighting which have been put into practical application have adopted constant potential direct current as the only satisfactory source of supply. The voltage varies from 30 to 110. The number and strength of lights varies through wide limits, some advocating 10 to 80 8-candle lamps per car, or 80 to 600 40-candle-power per car, some cars having as high as 26 50-candle lamps or 1300 candle-power per car. Tests made by the writer in 1900 showed an illumination in different cars varying from 0.008 to 7.5 candle feet. The stronger illumination is not only more pleasing to patrons and a conspicuous advertising agency, but further the flood of light effectually masks ordinary variations due to imperfect regulation.

The various plans for the supply of power for electric lights on cars may be classified as battery, dynamo and combination. The dynamo may be driven by an independent engine in the baggage car or on the locomotive, or it may be driven from the car axle. It may supply the lights directly, it may charge storage batteries or may combine the two. The battery may be large enough to supply all the lights through a single run or through a round trip, it may carry all the lights for only a few hours, or it may carry only part of the lights a short time for occasional use. Each of the various systems meets its own problems of mechanical, electrical and financial natures.

*Battery Troubles.*—When a battery is used without any dynamo on the train, it should have sufficient capacity to carry the load through the entire run without falling below normal voltage, a difficult task on long winter nights without excessive weight. Fortunately, the greatest amount of light is usually required when the car first leaves the charging station and when its voltage is highest; as the battery gives up its charge, the load generally lessens, and allows the voltage to remain fairly constant through the night. When properly proportioned to the load, the performance is excellent. For example, some of the Pennsylvania cars running between Chicago and Jersey City and charged only at Chicago, make the round trip with 32 to 24 volts at start and with 30 volts upon return. As the cells become old, however, their capacity decreases, and the battery lighted cars sometimes give unsatisfactory service toward the end of the run. For trans-continental service the unaided storage battery seems impracticable. The short time allowable for charging at terminal stations often involves excessively high rates of charging, and rapid lowering of the electrolyte. The difficulty of close and

thorough inspection of cells often results in no inspection until failure is reported. The difficulty of allowing good ventilation of the battery boxes while keeping out the dust and other dirt, involves difficulty from low insulation and from decay of the battery trays and boxes. Injury to car body and to battery boxes is minimized by liberal use of insulating paint, but seems difficult to avoid entirely. The shaking of the cells incident to railway usage causes somewhat more rapid deterioration than in corresponding stationary service. Slopping of the electrolyte is avoided by using deep jars with or without covers; the space is so fully occupied by the elements that there is comparatively little liability to slopping except in case of unusually violent handling of the cars. The weight of battery, including boxes, etc., on a car with "full battery" equipment is about 3,000 pounds, which is not a very large proportion of the total 91,000 pounds weight of a coach or the 116,000 pounds weight of a sleeper. The first cost of about $600 per car for "full battery" equipment, in addition to $300 to $400 for wiring, is not great in comparison with $8,000 to $10,000, the cost of a coach, or in comparison with $16,000 to $20,000, expended for a sleeper.

When the battery is charged during the run, there is more or less loss and deterioration due to the overcharging necessary to reduce the liability to failure on account of incomplete charging. The excessive charging and occasional over-discharging causes a more or less rapid deposition of mud at the bottom of the jars, which is liable to reach to the plates and so cause short-circuiting. The corrosion of connections due to the spray is frequently the cause of local action.

*Engine Troubles.*—On systems supplied from dynamos driven by steam engines, trouble is sometimes experienced from breaking of the flexible connection between the baggage car and the locomotive. It is common to use either the Moran ball-and-socket flexible joint or rubber hose strengthened by steel wire or expanded metal. The life of rubber hose varies from a few hours to several months. A blown-out hose can be renewed in a few minutes at the first stop of the train. There is sometimes trouble in disposing of the exhaust from the engine, which generally passes through the roof; when a good muffler is used, the grease is retained for the most part and is led through the bleeder through the car to the track, so that it is not carried back and deposited on windows and sides of cars. Sometimes in winter the condensed steam collects on the bellows of the car vestibules

to such an extent as actually to break the end of the car by the motion of the train. The reciprocating parts of the engines commonly used cause some vibration of the baggage car, which is transmitted through the couplings and may be felt to the extreme end of the train when in stations. The skill of the engineer in stopping the train is a large factor in the extent to which the vibration is felt through the train, it being least when there is a medium amount of slack. The adoption of the steam turbine may remove this difficulty. When the train is lighted from a dynamo and engine, some auxiliary source of light is necessary for the short intervals caused by changing locomotives, such relay being a storage battery or gas or oil lamps. The small engines use an excessive amount of steam per horse-power-hour. The labor cost is not great; for example, on the Chicago, Milwaukee and St. Paul road each train on a run of 400 miles between Minneapolis and Chicago is allotted four baggage men who receive $10.00 per month additional wages on account of attending to the electrical equipment, making a cost of $1.33 for wages for 400 miles. On the Northern Pacific road, the baggage man has more than one man can handle, and an electrician goes with the train to attend to the engine and dynamo and to help the baggage man when necessary.

*Axle System Troubles.*—One of the greatest difficulties has been to secure satisfactory mechanical connection between the car axle and the dynamo. Gearing, belting and friction drives have been attempted with some degree of success. The latitude of motion of the car axle in three dimensions imposes upon the dynamo drive very difficult conditions. This with the difficulty encountered from the dirt and stones thrown up by the motion of the train and from the steam and snow or rain which may freeze upon the belt, imposes a problem whose satisfactory solution has required great ingenuity and expensive experimenting. That the axle systems are being adopted extensively is a triumph indeed. Direct gearing similar to that used in electric railway practice has attracted many minds, the danger from a hot box or defective gear on a railway train drawn by a locomotive of several hundred horse-power is a very different thing from a similar defect on a car moved by the geared motor itself, which is protected by fuses and circuit breakers. The next great trouble is the wide range of speeds met in train operation and the necessity for maintaining constant voltage from the time when the train is standing, through the point where the dynamo cuts in and

takes the load to the highest speed attainable. The problem of regulation under such circumstances is one of no mean magnitude, and many are the ingenious plans proposed for its solution. Not only must the regulation take care of the varying speed of the train, but the battery voltage changes according to the state of charge, so that resistance or its equivalent must be inserted between the lamps and the dynamo or battery according to circumstances in order to keep the lamps at normal voltage. When one watches the operation of an axle lighting system which is so carefully designed and adjusted that no perceptible change occurs in the brightness of the lights between standstill and full speed, between the time when the battery is discharging and when it is charging, one can not but admire the success of the engineers in charge.

*Financial Considerations.*—All sorts of figures are given in connection with the cost of electric train lighting systems, some showing that each electric system is more expensive than any other, others showing that some particular electric system is the cheapest. The real cost varies greatly, according to the intelligence with which the whole plant is operated, this intelligence including both that of the engineer in immediate charge and that of officers of the road, who limit his facilities for proper handling of the equipment. In any case, the entire cost of maintaining the electric lighting system is a very small proportion of the entire cost of running the train, including not only the " operating expenses " but also that part of the general expenses chargeable to the particular train. The latter part of the cost, which is no inconsiderable part, is not usually obtainable. From the cost of operating the electric lights should be deducted the net profit from the added traffic which is attracted from other roads or which is created by the improved luxury of travel on electric lighted cars. These data are difficult, if not impossible to obtain with accuracy. If the added revenue created by the electric features of a train bears to the entire revenue from the train as great as or greater proportion than added cost of electric light, above other forms of light bears to the *entire* cost of running the train, then the electric light pays for itself.

## Discussion.

President Scott:—The subject is now open for general discussion.

Prof. Carhart:—If I am allowed to speak at all, I shall have to speak as a free lance, especially as I know nothing about the subject in hand this evening. I have been a little impressed in listening to the papers read here with the fact that I have been uncertain part of the time whether the expert was giving the prior art or whether he was telling us about present practice. I think there was rather too much of the prior art in some of the papers, if you will allow the criticism. I was also interested in Prof. Shepardson's paper in speaking of the low voltage used in train lighting, which feature is very desirable because it avoids any accident in case a passenger comes in contact with the conductor. I have known cases on the Pullman cars where the passengers came in contact with two conductors at once; and my friend, Mr. Smith, says they may come in contact with three, the other two and the electrical conductor, and so I suppose that would be a three-wire system.

The thought occurred to me while we were hearing about these elaborate systems to secure constant voltage, and certainly they are ingenious—I admire greatly the ingenuity displayed in these two systems for securing constant potential—the thought came to me, why is it not possible to use the mercury vapor lamp which does not require a constant potential. Mr. Steinmetz tells us in a recent paper that the mercury vapor lamps will work between a very wide range of potential without any particular difference in the light given out. If that is so, we do not need these elaborate devices for maintaining constant potential. Mr. President, I am not able to contribute anything else to this subject, because I have not studied it.

President Scott:—The subject is open for general discussion.

Mr. Lamar Lyndon:—Some of the papers read this evening have seemed to assume that speeds of sixty miles an hour are sufficient. We have been informed by certain railway men that there are times when speeds of eighty-five miles an hour are attained for short stretches. No matter how short these stretches may be, the car lighters must be designed to take care of such excessive speed. Then, in regard to the battery end, there seems to be a disposition on the part of designers to take it for granted that a battery will maintain about two volts. It will not. A battery will require, in order that it shall be properly taken care of, a charging current that will run as high as 2½ volts. It must be discharged down to 1.8 volts. That is a variation of .7 volts, or about 30.5 per cent., taking 2 volts as the normal. These systems mostly assume that a constant current will flow into the battery, and that with variations of current we have variations of electromotive force, at the terminals, which is true; but we have further variations of electromotive force at the terminal due to the changing condition of the battery, and any system based on

charging with a constant current or maintaining a constant current through the battery cannot maintain the batteries in good condition. The proper way to charge the battery is that the current shall go in rapidly, when the battery is fully discharged, and that the current shall gradually be reduced until the battery rises to its maximum voltage, and in order to do that the generator must raise its voltage continuously with that of the battery, but not in such manner as to cause a constant current to flow through. A proper system must contemplate such a continuous rise in the voltage, that when the battery is fully charged, practically no current will flow through it; and those constant current systems, or systems which assume a constant current, will not maintain the battery in good condition. It must be what is technically known as "boiled" at times, or overcharged.

Mr. Farnsworth has stated that about 90 per cent. of the systems throughout the world use a belt drive. That is true, because they were originally developed abroad where the systems are very small and the lighting of a small English or German passenger carriage, and the equipment required, are by no means comparable to the lighting of a Pullman car in this country; and it is a difficult matter to drive such a generator with a belt, or take care of the generator or regulate it by belt slippage. I know of one system which was originally used in England and the patent rights for its use in this country were purchased here; and after the system was brought here it had to be totally re-designed for American service, and it took three years to get it in proper shape.

I would like to ask Mr. Bliss if he will please explain more fully the triple-contact employed in his system.

MR. BLISS:—I do not think I can explain it in any more concise form than to read the description of it in the text.

PRESIDENT SCOTT:—If the matter is fully described in the text of your paper it is hardly worth while to take time to read it.

MR. BLISS:—I will make this explanation, however. The triple contact shown in the diagram, Fig. 7, is drawn in duplicate which makes it appear as if there were two such contacts. As a matter of fact there is only one. It has been transferred from its true position as a part of the generator switch, to a position near the bucker simply to show more clearly what the contact is for, and how it is connected. If the wires leading to it were carried across the diagram there would be some confusion with a number of crossings, and it would be more difficult to understand. We call it a triple contact, because there are three things connected together by the plug. The three segments shown are connected respectively to the negative lamp main, the negative of the generator and the negative of the storage battery. You can see that when the batteries discharge, current will flow from the positive pole through the lamps, lamp bucker and backward through the series field to the negative pole of the batteries. There is a little drop through the lamp

bucker and series field, and it is desirable to short circuit these parts by connecting the negative lamp main directly to the negative of the battery. Such a short circuit would, however, convert the lamp bucker and series field into a local short circuited series dynamo, in which a heavy local current would circulate. To prevent this the negative of the generator is connected to the third segment of the triple contact, which short circuits both series field and lamp bucker, thus rendering same absolutely inoperative. The plug connects the three segments together just before the generator switch opens. Thus, at speeds below 20 miles per hour, during which the generator is disconnected from the system and the services of the bucker are not required, the latter is completely cut out or short circuited.

When the generator has attained a speed corresponding to 20 miles per hour, the generator switch closes, and at the same time breaks the triple contact. The parts of the bucker are now free to act as soon as current flows through the series field in the charging direction. As explained in the text the bucker is prevented from becoming a booster when current flows in the wrong direction through the series field by causing the motor armature current to return to the generator through the series field, but in a direction opposite to such improper discharge current. The simplest way to connect the motor would be directly across the generator mains, but as pointed out it is more advantageous to connect it as shown. The triple contact also serves to cut resistance in and out of the circuit of the lifting coil of the generator switch as described in the text. This arrangement also makes it possible to reduce the size of the switch and its cost of manufacture.

PRESIDENT SCOTT:—The Secretary has received a telegram reading as follows: " Please invite in the local Philadelphia Committee's name, Messrs. Bliss, Farnsworth and Sperry, to present abstract of their papers at local meeting, March 9th. W. C. L. Eglin."

The Philadelphia Local Branch is to inaugurate its work on March 9th, at the rooms of the Engineers' Club at Philadelphia. I extend an invitation to the gentlemen named to be present at that time and ask them kindly to communicate with the Secretary whether they can be there or not. I would say to the other members of the INSTITUTE who can conveniently be in Philadelphia at that time, that I am sure the Philadelphia members will appreciate very much your attendance at their meeting.

Mention has been made of the mercury vapor lamp. At the meeting of the Pittsburg Branch recently, at which the subject of illumination was discussed, a short paper was presented upon the Hewitt lamp by Dr. von Recklinghausen. He is with us this evening, and will, I think, give us a few remarks upon that lamp.

DR. MAX VON RECKLINGHAUSEN:—A few of the gentlemen have mentioned the mercury vapor lamp to-night in connection with

its possible use for train lighting. I am afraid they will be up against the same problem that we of the Cooper-Hewitt Company are up against in trying to persuade the public, especially the ladies, to consider the mercury vapor lamp a nice light. As to the lamp being put to such use under the varying voltages which are met with in train lighting, that is a thing I cannot say very much about, practically nothing, except that it is a very ticklish question and not at all as simple as it may seem to be from a recent publication. I do not think we are in a position to say anything about the vapor converter just now.

PRESIDENT SCOTT:—A gentleman who can talk on this subject, not from a theoretical standpoint, but as the result of large practical experience, is Mr. George W. Blodgett, of Boston. I believe he is present and we should like to hear from him.

MR. BLODGETT:—I had some experience quite a number of years ago in lighting cars electrically by the use of storage batteries. The Boston & Albany Railroad fitted up two trains running between Boston and New York, and for two years lighted them entirely by the Julien storage battery system, a battery being placed in each car. At first the batteries were charged only at one end of the line; but when it was found unsatisfactory to attempt to make a round trip with only one charging, arrangements were made to charge the battery at each end of the line. A switch was placed in each car which, thrown in one position, put all the cells in series. There were two batteries, one on each side of the car, which were put in series for charging, and also connected to a pair of dynamo terminals under the car on each side, and it was then only necessary to insert a pair of plugs in these terminals, which were of different size, so the poles from the generator could never be misplaced and the battery be discharged instead of charged. This was connected to an arc light direct-current circuit, which was the only means available for charging the batteries. Throwing the main switch in the car into the opposite position, put the two batteries in multiple and connected them to the lighting circuits, the lamps being turned on by a snap switch such as are employed in other lighting circuits. Had the storage batteries then used been of as durable quality as are now manufactured, I am not sure but the trains would be running to-day; but the deterioration of the batteries was a source of very great expense, renewals requiring to be made constantly so that the battery gave rather unsatisfactory service. The reason for discontinuing the lighting of these trains by electricity at the moment when it was done, was the shutting down of the electric lighting plants in New York City for a time, which prevented the batteries being charged at that end of the line; and it was necessary, therefore, to stop the electric lighting.

Some interesting things were found out about the lighting of cars with storage batteries, and it was a very instructive experiment. I think I am correct in saying that these were the

first trains ever equipped for being lighted entirely by electricity. I am open to correction if I am wrong, but I believe that is the case. I hardly think there are any more facts of importance to communicate, unless some one has a question to ask.

A MEMBER:—In what year did this experiment take place?

MR. BLODGETT:—The experiment began in 1887 and ended in 1889.

PRESIDENT SCOTT:—The subject is now open for further discussion.

MR. C. W. HOGAN, Harrison, N. J.—Mr. Farnsworth stated in his paper that the voltage variation can be kept within 4 or 5 per cent. I think in central station arrangements the variation is 2 per cent., or thereabouts, that is, with lamps requiring from 3.1 to 3.5 watts per candle. In train lighting, where they use such an efficiency as Mr. Farnsworth states, 2.5 watts per candle, such a variation would bring the lamps to 2 watts per candle, and would have an appreciable effect on the life of a lamp, on its maintenance of candle power, and its general appearance in the car. I think if this system of train lighting is to become a success, that this variation of 4 or 5 per cent. will have to be materially improved, from the standpoint of the life and maintenance of the candle power of the lamps.

MR. FARNSWORTH:—In regard to the point just brought up, the voltage of the lamp plays a very important part. For instance, a low voltage lamp, 30 volt lamp, has a stronger filament and is not so delicate as a higher voltage lamp, of the same candle power and efficiency; and although the life of the lamp is not particularly long, it is sufficiently long.

MR. LOCKWOOD, Detroit.—Is the discussion open to others than members of the INSTITUTE?

PRESIDENT SCOTT:—We would be pleased to hear from you.

MR. LOCKWOOD:—I have listened with a good deal of interest to the papers read to-night, and noted in Mr. Sperry's paper the statement that "A perfect system rquires that every car shall be entirely independent of every other, and shall maintain its lights perfectly after the train is broken up." It seems to me there should be added to that—and should be as simple and with as few moving parts as possible. On that point I would mention it is but a week since that one of the manufacturers of steam turbines informed me that his company had orders for a number of steam turbines to drive generators for use in train lighting. I note the title of the subject under discussion is "Railway Train Lighting," but the three different papers have simply described systems pertaining only to axle-driven machinery. If something could be heard about what has been accomplished with steam-driven machines, and also from the railway standpoint how the two systems are viewed comparatively, it would be interesting; because with the axle-driven machines, on the average train of from six to twelve cars, it means six to twelve equipments, with the necessary multiplica-

tion of parts, while with the steam-driven equipment but one would be needed for each train. It seems to me that simplicity is the most important point unless experience has proved it to be a failure.

MR. BLISS:—We have with us to-night a gentleman who, I think you will agree with me, has probably had more experience on this subject than any of the rest of us here present, and that is the electrical engineer of the Pullman Palace Car Company, Mr. J. R Sloan.

MR. SLOAN:—Mr. President and Gentlemen:—I regret exceedingly that my position and the Company's are such that it is not considered desirable I should take part in this discussion. I thank you very much for the invitation.

PRESIDENT SCOTT:—There is another system of train lighting which has barely been mentioned, but not commented on to-night. A brief reference was made at one time to the stage coach, with horses furnishing the motive power, and nothing but a candle light to supply a little illumination. Later we come to the railway trains, driven by steam engines and lighted by oil lamps. When we try to transform part of this latter equipment and furnish electric current for illumination, various difficulties appear. Instead of doing part of the work with electricity, why not do it all? Let electricity take the place of the horse and the candle and also of the steam engine and the dynamo and the battery, and let us run the car and do the lighting by the same agent, and see how simple it will be. Mr. Henry G. Stott, electrical engineer of the Manhattan Railway Company, is running a system of that kind, and we would be pleased to hear from him.

MR. STOTT:—I was thinking how easily we could solve the problem in the way you indicated just now, Mr. President, taking the whole car and applying electricity to it in its entirety instead of to a part of it. I have been interested in the papers presented to-night. They have been as much a revelation to me as were the papers which we heard on the electric brake, two months ago. It is apparent that much work has been done in a quiet way in the most scientific manner, to solve the problem of train lighting difficulties. Those engaged in what might be called heavy electrical engineering perhaps neglect these points, and I think it is an extremely interesting development of the subject to find there are so many by-ways in electrical engineering of which the general profession hears nothing at all until the reading of a series of papers such as we have had to-night on this subject, and the papers on the subject of electric braking which were previously presented.

In Mr. Sperry's paper, reference is made to a new system. That is all we have heard in a definite way, and I would like to have a little further information on that point. The papers presented by Mr. Farnsworth and Mr. Bliss are so able in themselves as to be beyond criticism. Mr. Bliss' paper especially

shows us what can be done, not only in maintaining constant potential in lighting trains, but I think can be applied in many cases to obtain constant potential where we have variable sources of power, such as water power. I think in such cases the application would be a very similar one.

PRESIDENT SCOTT:—Is there any one present who is able to give Mr. Stott the information he asks for?

MR. SPERRY:—In reply to our President's remarks and those of Mr. Stott I find myself in the position of one having accepted an invitation to present a paper and at last moment finding that *Hamlet* had to be omitted, but the author not released. At no distant date will I be able to answer Mr. Stott fully, but the one who is responsible for a large part of the work that I have attempted to describe is here with us, and I should like to hear him say something with reference to the details asked for by Mr. Stott. I refer to Mr. Lyndon.

MR. LYNDON:—I should like very much to say all that I can about this system which has kept Mr. Sperry and myself very much engaged for the past eighteen months, but we were told to-day by our attorneys that we could not do it; and, therefore, I think that Mr. Sperry's suggestion that I should speak to you on this matter is getting even with me for something I never did.

PRESIDENT SCOTT:—The attorneys must be respected, but we are glad to know, in a general way, the information which you have given about the system.

MR. LYNDON:—I think in explanation, Mr. President, that I should say that when we agreed to present this paper it was supposed our arrangements would be completed before the paper would be presented. We did not intend simply to give a general paper to the INSTITUTE, but to go into more specific details. We have, however, lately been informed that the arrangements were such we could not give any more than we have.

PRESIDENT SCOTT:—Is there any further contribution to the discussion?

MR. W. N. SMITH:—As one of the recent speakers remarked, nearly all of the subject matter of the discussion to-night has been on axle-driven systems. The ingenuity the members have displayed is truly remarkable. At the same time, quite a little car-lighting is done by the old-fashioned steam engine driving a direct coupled generator in the baggage car. None of the gentlemen have stated how long or on how many trains their respective systems have been in successful operation, and it seems to me that a little information as to what the commercial results have been, would be fitting in this discussion. I believe the system that I have in mind with a high speed engine and generator in the baggage car, receiving steam from the locomotive, is applied to most of the finest and fastest electrically lighted express trains on quite a number of the principal railroads of this country, like the New York Central; Lake Shore; Chicago and Northwestern; Chicago, Milwaukee and St. Paul; Northern Pacific, and several

others. It would be very interesting, indeed, if we could hear upon what railroads these axle-driven systems have been applied, and how many of them have been accepted and are in daily use on the prominent railroads of the country.

MR. BLISS:—I regret that Mr. Sloan cannot tell us something about the lighting on the Pennsylvania Limited, of which he has immediate and direct charge, but as he seems to be reluctant about doing so, I will venture a few remarks on that subject myself, and stand correction from him or anyone else if I am in error.

The system of lighting on the Pennsylvania Limited which is probably the most celebrated train in the country, consists simply of an engine and generator in the baggage car, train lines through the train and storage batteries on the cars. For many years they have employed a Brotherhood three-cylinder engine, directly connected to an Eickmeyer generator, running at 800 r.p.m. The system is not complete. At best, these generators could furnish just about enough current to charge the storage batteries alone or else light the lamps alone. When charging the batteries, it was not safe to use the lamps on account of the high voltage, but as a matter of fact there was not sufficient power in the engines to perform both operations at once. When the Brotherhood engine was in good condition, it developed a horse-power-hour with something like 80 lbs. of steam, but I have heard that nearly 500 lbs. of steam have been consumed per horse-power-hour in actual test. Within the last few months, there has been installed a De Laval steam turbine driving a generator at 2,000 r.p.m. The apparatus runs very satisfactorily and shows a good steam economy, about 25 lbs. of steam per horse-power-hour. This new equipment takes up more room than the original plant, and requires the constant care of an engineer. It occupies practically one-quarter of the space devoted to baggage, the car being a combined parlor smoker and baggage car. There is ample power in this plant to charge the batteries and light the lamps. The machines run smoothly and without vibration, but make a great deal of noise by reason of the gears, which operate at such high speed. The noise cannot be heard outside of the baggage compartment and no vibration is communicated to the train, as was observable, for instance, on the Lake Shore Limited, where the knuckle in the coupler on the rear car could be seen shaking when the train was standing at a station with the engine and generator in operation. As a system, the turbine set is no better, except in economy, and greater capacity than the original plant, which it has replaced. The difficulty still to be overcome is that the storage batteries cannot be charged and the lamps lighted at the same time, and the batteries on this train, with its turbine generator and up to date equipment, still have to be charged at Jersey City and Chicago as of old. A number of devices have been suggested whereby resistance or something equivalent could be thrown into the lamp circuit to maintain

proper voltage on same, while the batteries are being charged; but these devices, if automatic, are difficult to make, and if the porters are to be depended upon to operate them, they will be unreliable. It seems to me that a system is necessary whereby the lighting of the lamps and the charging of the storage batteries can be carried on simultaneously without any rise in voltage on the lamp circuits. Thus we see to-day, on the best-lighted train in America, the Pennsylvania Limited, the system of lighting is very far from being perfect and in fact as a system it is not much better than it was fifteen years ago.

MR. SPERRY:—I would correct a statement of the next to the last speaker, that the fast trains are all fitted with dynamo sets. As I understand, that is not true. The Twentieth Century Limited, and all that series of trains, have axle-driven equipments, and there are some other fast trains with axle-driven equipments as against the system of employing a single generator for the entire train. The want of discussion on this type is, I think, owing to the fact that in this case, employing the single generator in the train, we have conditions similar to those of a central station with its coupled lamps. It entails no special problem, and the discussion to-night has been on the special problems which are presented in axle power, and which have been overcome in such meritorious ways as we have heard described.

With reference to the detail of the system, which I was invited to describe and which at one time was described in my paper and afterwards expunged, I would say that the generator is simply a constant speed machine. The item of regulation is reduced to a very simple and straightforward mechanism, which is introduced between the driving axle and the dynamo, in which it differs from the present types of car lighters, which are variable speed machines and which must have the variable voltage compensated for in the electrical system. The load comes on at 1,200 revolutions, which corresponds to 18 miles an hour train speed. When the car runs at 80 or 85 miles per hour, the 1200 revolutions are still maintained, thus eliminating the more complex problems involved in the electrical control and some of the complexities which exist in the other systems. One of the special points sought is the handling of the batteries in accordance with the best practice of charging storage batteries, not utilizing a small portion only of the range, but utilizing the battery throughout its whole range of possible operation, and maintaining the voltage of lamps within one half of one per cent., instead of the large percentage of variation that we have heard discussed to-night. This permits of the use of more delicate lamps—higher efficiency lamps, I might say. These features are among the essential points of difference between this and the other axle systems about which we have had the pleasure of hearing to-night. Another essential is the automatic charging with lowering current when battery is nearly charged, and still another is the utilizing

of measurably 100 per cent. of the normal capacity of the cells, thus keeping them in a healthy state, and requiring only a comparatively small weight of battery aboard.

I referred in the paper to a series of investigations that were conducted where I had an opportunity of observing the operation of the systems; a peculiar phenomenon in the case of one of Bliss' equipments came under my notice, which I think we would be interested in hearing Mr. Bliss explain; and that was the almost inexplicable fact that upon the accidental or other opening of the battery circuit, instead of putting the lights out, or cutting down the voltage at the lamps, all of the lamps in the car went *up and out;* and the voltage rising until the lamps and filaments were exploded. I have looked through the diagram and paper which Mr. Bliss presented to-night, but fail to see any reason given why this should have occurred; possibly he will explain it for us.

MR. BLISS:—In answer to some of Mr. Sperry's remarks, I would say, in regard to the transmission of power from the axle to the generator, it seems to me that the problem is much like that in a street railway motor, and we can be guided in dealing with it by the experience of those who have worked that system out to perfection. When Mr. Sperry speaks of a constant speed generator, it pre-supposes, that there must be something in the transmission that secures the constant speed. It seems to me simpler to allow the speed of the generator to run wherever it will and take care of it electrically which can be done more easily than it can be mechanically.

In regard to the other point which Mr. Sperry brings up. If the storage battery circuit is broken, what will happen? If the battery circuit opens, the regulating current through the series field is interrupted and the voltage of the generator will rise abnormally and may result in great damage. We do not furnish the storage batteries and are not responsible for them. Is it, however, incumbent upon the storage battery people and the railroad companies to see that the lugs and connections of the storage battery are properly made and installed. We have introduced a device which I have not touched upon to-night, not because my attorneys have advised me not to, but simply because I have not so chosen. I am free to speak to you of this device, whereby the destructive effects of excessive voltage are avoided. This device was made necessary principally through the repeated breaking of the storage battery lugs, for which we are not responsible, but which, nevertheless, reflects upon us. This device is simple in its construction and will act in two ways. It will prevent an abnormal rise in voltage in case the storage battery circuit opens and it will also operate to discontinue the charging of the batteries, when the latter have become fully charged.

One other point Mr. Sperry brought up. He said that a train equipped with an engine, generator train lines and storage bat-

teries was simply a small central station and introduced no new problems to solve. But the problem has not been solved at all. As a system it is incomplete and it is not even a self-supporting central station in the sense that it is independent of outside power. Terminal charging still has to be depended upon. The engine and generator in the baggage car will not maintain light in the passenger cars in the present state of development of this system.

MR. JAMES F. MCELROY:—I did not intend to take part in the discussion on this subject, but since entering the room the Secretary has requested me to say something about the system of axle lighting with which I have been experimenting for several years, and I may wish the privilege of publishing, in the report of this meeting, a short article descriptive of that system, if it is in conformity with the rules of the INSTITUTE.

PRESIDENT SCOTT:—That will be satisfactory.

MR. MCELROY:—I will say that in my experiments, I have tested almost every conceivable apparatus for driving from the axle. My first experiments included the use of belts made of leather of single and double thickness; part of these were wide belts and part narrow. I have also used rawhide belts, the so-called camels' hair belt, rubber belts, link belts, and I have lost so many belts that I have called the line between Albany and Montreal, where my apparatus was in use, "the belt line." I employed a tension device to maintain the proper tension upon the belt. In one set of experiments I attached the generator to the bottom of the car and undertook to drive direct from the pulley on the axle. I also made another device in which the dynamo was capable of a side motion so as to maintain a parallel position between the dynamo shaft and the car axle. I found that whilst certain difficulties could be removed, other difficulties persisted throughout my experiments and caused me to abandon the use of belts. For example, I found that a belt which would run all right when dry would not run satisfactorily in wet weather; or belts that operated when the thermometer stood at 40 or 50 degrees above zero would not act properly when the thermometer fell to 20 degrees below zero. The heating apparatus on the car, discharging the water of condensation, may have been in a measure responsible for the formation of ice over the pulleys and for the consequent lack of adhesion between the pulley and belt.

I remember leaving Albany on the sleeper one night at 11 o'clock, bound for Montreal. The next morning, as we approached Montreal, I stepped into the car just ahead, which was equipped with my lighting apparatus. The lights were running all right, but when the train stopped I noticed that the pulley on the axle had a half inch thickness of ice upon its surface between the belt and the pulley. You must admit that such conditions are not favorable to the use of belts.

Now, there are some peculiar difficulties in the use of belts for

this apparatus. The question of adhesion between the driving pulley and belt is by no means the only one. I believe that the question of alignment introduces some very serious complications. I have found that an axle on a straight track does not maintain a position perpendicular to the line of the rails or to the line of the car. It is well known that the tread on a car wheel has a larger diameter near the flange of the wheel than it has at the outer edge. There is a play of fully half an inch between the flanges of the wheels and the rail. The result is that when one flange crowds up against the rail, that wheel runs on a larger diameter than the opposite wheel on the same axle. The first wheel, therefore, moves forward more rapidly than the opposite wheel, and this motion then crowds the flange of the opposite wheel against the rail, when it in turn drives forward more rapidly. The result of this peculiar action is a see-sawing of the car axle. in which it moves so as to bring alternate flanges in contact with the rail and at the same time the axle is given a to and fro motion, lengthwise of the axle. This complicated motion introduces difficulties when you attempt to drive a dynamo with a belt on a pulley on the axle, as it causes the belt to see-saw across the face of the pulley, striking the flanges on both sides and causing the tension to be thrown first upon one edge of the belt and then upon the other. This action results in stretching the belt along its edges.

The axle also has another motion which is especially noticed when the air brake is applied, which pushes the axle towards the king-bolt and thus increases or decreases tension upon the belt, depending upon which side of the axle the dynamo is supported.

Another difficulty in the use of belts is caused by the spring used to maintain tension upon the belts. When an engine backs on to a train so that a shock is given to the car, a severe blow is given, which causes a sudden increase of tension upon the belt; or if the blow is in the opposite direction, causes the tension suddenly to release, when the spring device will then pull the dynamo back quickly, when it strikes with heavy force within the belt. As a result, belts are often broken in the making up of trains at the station

I feel quite at liberty, Mr. President, to speak of my experience with belts, since my experiments in car lighting have carried me to a point where belts are entirely discarded. I have no reason to believe that my experiments with belts in lighting apparatus were any more unsatisfactory than the experience of other companies in the use of belts. I believe that the experience of all companies attempting to operate lights from the axle by means of belts, is that the belts have been short-lived, unreliable and unsatisfactory.

In my own apparatus I now use a gear and pinion somewhat resembling the arrangement as used on the electric cars. The gears are noiseless, giving a positive drive, and the wear for the last year indicates that the gears and pinions can be furnished at a cost not exceeding $5 per year.

Reference has been made by two of the members in the discussion of the storage battery and the fact that the storage battery when nearly depleted should receive current at the maximum charging rate, and that as the charging operation proceeds, the rate should be gradually reduced so that by the time the battery begins to gas at the completion of the charge, the flow of current through the battery should be reduced to a minimum. I fully agree with that statement as to the proper method of charging a storage battery, and I desire to say that I invented and have had in use for a number of years a method of control which enables me to charge a storage battery precisely in accordance with the formula as laid down by storage battery makers. In other words, when the battery is depleted, the charging rate is at its maximum, but still within bounds. The charging rate gradually tapers as it approaches complete charge, when the sudden rise of voltage, due to gasing of the battery, after the completion of the charge reduces the current to zero. This result is accomplished in the regulator by the use of a peculiarly constructed suction coil. The plunger of the suction coil is drawn out by a spring under constant tension. The pull of the suction coil then consists of two parts—the charging part, due to a shunt coil and the other, a minor part, due to a small series coil, which is placed preferably in the storage battery circuit. The total of the pull of the shunt and series coils is equal to the tension of the reacting spring. The result is that the voltage maintained in the charging of the storage battery is a modified constant potential, being lower when the battery is depleted than when the battery becomes fully charged. The greater flow of current to the battery, when depleted through the series coil, is accompanied by a smaller pull on the part of the shunt coil. As the counter electromotive force of the battery increases, the decreased flow to the battery through the series coil causes an increase in the pull of the shunt coil, due to the rise of voltage.

The result is that by adjusting the number of turns of the series coil, the rate of charging a storage battery may be brought absolutely under control, in accordance with any prescribed formula. I will say that whilst this method is patented, it may be of interest to you to know how this problem has been worked out.

PRESIDENT SCOTT:—A sentence in the paper submitted by Prof. Shepardson is well worthy of repetition, as we all agree that it is the sentiment of the whole trend of the evening. He says, "When one watches the operation of an axle lighting which is so carefully designed and adjusted that no perceptible change occurs in the brightness of the lights between standstill and full-speed, between the time when the battery is discharged and when it is charged, one cannot but admire the success of the engineers in charge." The whole discussion this evening has been a demonstration of the manner in which electrical engineers have attacked and solved some very difficult problems. I think the

great value of a meeting of this kind, with papers of the type which we have had, and with discussions and debates embracing experiences such as have been presented to us to-night, lies in this—that it presents the problem definitely to others and deters them from going over the same ground and making the same mistakes. Train lighting is a very attractive subject. As soon as one comes to understand a few of the difficulties which have confronted inventors in this and other lines of work, we begin to appreciate the effort which lies behind what are apparently simple inventions. A young man just beginning to try his intellect in an inventive way is apt to contrive some little device which will overcome some difficulty and then he thinks he has solved the whole problem; but this, as we know, is not often the case. If such a young man has been here this evening or will read the proceedings of this meeting, he will get a good deal of light on these lines. It will show him that many practical problems, simple as they may seem in themselves, really involve a great deal. Whole series of problems arise and if one attempts to investigate them and does so in ignorance of what others have done before him, he is apt to subject himself to an indefinite number of disappointments until he properly appreciates the fullness of the problem, in a manner such as we have appreciated the difficulties of train car lighting presented in the discussion this evening. If there is no further business, the meeting stands adjourned.

(Adjourned.)

## BRANCH DISCUSSIONS.

### Discussion at Pittsburg, March 12, 1903.

*Programme:—*

The meeting was called to order by Chairman P. M. Lincoln, at 8.15 P. M.

The following papers were presented:

1. "An Electric Car Lighting System," by Wm. L. Bliss. abstracted by N. W. Storer.

2. "Axle Lighting," by Elmer A. Sperry, abstracted by B. B. Abry.

3. "An Axle Light System of Train Lighting," by Arthur J. Farnsworth, abstracted by S. M. Kier.

4. Resumé of New York Discussion, by Miles Walker.

The discussion was participated in by Messrs. P. M. Lincoln, J. S. Peck, N. W. Storer, A. H. Masters. B. B. Abry, J. M. Campbell.

Mr. Lincoln:—I note that Mr. Walker, in classifying the papers discussed at the New York meeting, divides them in two classes: Class 1, did not know anything about it; and Class 2, knew all about it but said nothing. I suppose if we were classified we would come under the first class.

Mr. Peck:—I think, after striving to follow through the diagrams of connection before us, we feel with Mr. Lockwood that no complicated system can live. I understand that Mr. Storer has a system which is extremely simple as compared with these, and if Mr. Storer is not in the hands of his attorneys we should like to have him explain his system.

Mr. Storer:—It is a great surprise to me to be called on in this way, but as my attorneys have not commanded silence I will give a brief description of a generator which I once designed for a train lighting system. It is, of course. in common with all the other systems that have been presented to-night, much better than anything else that was ever proposed.

The systems which have been presented here to-night remind me very strongly of the time I attempted to study out the connections of a well-known multiple-unit control system. There was such a maze of wires, connections, solenoids, etc., as almost to make one's head swim. This, of course, does not necessarily mean that the system would not work, for there is no doubt that a system, whether of control or train lighting, may work satisfactorily and still be extremely complicated; but it is an undoubted fact that the more parts there are in any system, the more likelihood there is for that system giving trouble. The great criticism which everyone must make on the systems which have been presented to-night is that they are very complicated. In this as in other branches of electrical engineering every endeavor should be made to simplify and reduce the number of parts.

The generator which I designed some eight or ten years ago

was a small 4-pole machine, designed to give a constant current of approximately 20 amperes and an electromotive force of approximately 50 volts over a wide range of speed, corresponding to a train speed of from 20 to 60 or more miles per hour. It was designed for gearing direct to the axle like an ordinary street car motor. The regulation of the machine was obtained in the same way as the regulation of the Westinghouse direct current arc generator system, which was introduced at that time. The field was separately excited and the armature reaction was so proportioned as to keep the current practically constant over a wide range of voltage, if run at constant speed; or a constant current over a wide range of speed if run at a constant voltage. The machine being connected to the battery terminals, the voltage was practically fixed and therefore the speed might change from the minimum at which the machine will give the battery voltage, to the maximum speed that the car will run, and the generator would still deliver 20 amperes. I may say that this system was never entirely worked out, as it was not thought advisable by the company with which I was connected to go into the train lighting business at that time. Consequently the matter was dropped. But the advantages which I could claim for this system are the inherent regulation of the generator, which I believe would obviate much the larger part of the automatic apparatus which is found in the systems which have thus far been presented. The fluctuations in voltage would certainly be very much reduced, as from the time the generator is cut into the circuit until it is cut out again, it will deliver a constant current. The minimum voltage would therefore be supplied when the generator is cut out of circuit and the battery delivering the entire current required. The maximum voltage on the lamps would be obtained when the load is reduced to a single lamp, and the remainder of the current used in charging the battery.

In any well-regulated system, the generator should not furnish much more current than that required for operating the lamps, motors, etc., which form its load. The battery should be charged, for the most part, at times when the load is off. Consequently, there need not be such wide fluctuations of voltage on the system, and there would be no use for the " bucker " or the series resistance.

The system described by Mr. Bliss is admirably worked out and will doubtless give excellent results over the range of speed for which it is adjusted, but there is too much apparatus. The system employing the series resistance must be placed in much the same class. Until Mr. Sperry's system is placed in operation, we must take his word for it that it is a perfect system. Personally, the lighting of the train from a single generating unit placed in the baggage car or on the locomotive appeals to me most strongly. The system is extremely simple and the apparatus is at all times under the control of an expert attendant. All

of the apparatus but the storage battery is removed from the car; the battery must be used to supply the lights when the car is cut off from the generator.

MR. MASTERS:—I am familiar with the system of car lighting adopted several years ago by the Consolidated Car Heating Company, of Albany, N. Y. No mention has been made of it tonight, possibly for commercial reasons. At that time this company had cars in operation between Albany and Montreal, on which they were experimenting. They took the same stand that has been taken here,—that complicated systems are not at all likely to succeed, and less likely from a commercial point of view than from any other.

There seem to be diverse opinions regarding automatic qualifications for the successful operation of an axle system. Viewing it commercially, I understand the Consolidated Car Heating Company to maintain that an equipment costing more than $700 or $800 would be objectionable to railway interests. They stated that so far as they were able to observe, the road for which they were then experimenting would approve any system that would not cost more than $800 per equipment. Complicated systems, involving many automatic principles, are, it seems to me, so expensive that they would probably not be considered at all.

Speaking about storage batteries, I think the same remarks hold good, not only in the equipment but in the maintenance of these batteries. Many arguments are advanced by the electric storage battery companies that their batteries are giving good life. My experience with storage batteries in the past has been that they do very well at start, but when you work them for transportation purposes, troubles arise which runs up the expense of maintenance very materially.

MR. ABRY:—I have been very much interested in the discussion of train lighting this evening. A comparison of the axle-lighting system with other systems and the disadvantages, particularly of the axle-lighting system, recall to my mind some difficulties we had to overcome in the measurement of speeds in some tests that we made on the Union Traction Company of Indiana. For measuring the speed, we employed a magneto-generator which was driven from the axle of the car by means of a belt. The magneto was first placed on a small platform, bolted to and extending directly out under the car from the yoke of the truck. This inclined the belt at about an angle of 45°, The results obtained were not very satisfactory. Finally, we suspended the magneto on a bracket still bolted to the yoke, but so arranged that the travel of the belt was nearly parallel to the track. We calculated the size of pulley needed on the car axle, to give the required speed of the generator; this pulley was turned with a small flange and with a face slightly wider than the width of the belt, which was one inch. Upon making a trial run under these conditions, we soon found difficulty in keeping the

belt in place, and, as Mr. Walker said, there were belts all along the line. We found there was a lateral play in the car axle of two inches, more or less, besides the vertical motion due to irregularities in the track. The belt would not stay on. There was a continual tendency to climb over the flange of the pulley whenever the side play of the car axle became excessive.

We also had trouble at first with moisture softening the cement and the belt coming apart. We overcame the difficulty incident to the belt jumping by having a new pulley made with a flange about an inch in height, and the face of the pulley about twice as wide as the belt itself. After properly aligning the apparatus and mounting the magneto on springs, we finally obtained fairly satisfactory results.

The simple experiment of measuring speed on an interurban car seems to me to point very conclusively to the disadvantages of an axle-lighting system. I have observed on three of the principal roads of the West, the C. M. & St. P., the C. B. & Q., and I think the Santa Fe, the use of the system which is employed on the Pennsylvania Limited trains: viz., a generating unit with auxiliary batteries. In view of this fact, that system certainly must have some good features.

MR. CAMPBELL:—In general, it might be a good deal better to have a separate engine and generator in the baggage car, but what about lines where you have only a few cars electrically lighted? It would be out of the question to equip every baggage car or every passenger engine with a generator outfit of a capacity large enough to supply any combination of cars that may be attached to a train, for the sake of a few cars electrically lighted that may from time to time be used. Axle lighting is also preferable for a class of cars known as private cars or official cars, of which there are not a few. These frequently leave the home road and therefore should be self-contained, as it is not likely that all lighting systems would have the same voltage. On one road running out of Pittsburg they have the system discussed in Mr. Farnsworth's paper and the generator works very well. We had trouble for awhile with belts not staying on; they would get loose and slippy. That trouble was very largely overcome by changing the belt from a flat one to a V-shaped, short lengths of V-shaped pieces of leather are fastened to a flat belt and fit into V-shaped pulleys. These belts work well. We have had them last as long as a year, which seems a reasonable time. We found one trouble with the system; the adjustment of the main solenoid seemed somewhat delicate, but after being once set would maintain a nearly constant current. On cars running from 20 to 70 miles per hour, I have seen the current remain at about 32 amperes. The voltage does not remain altogether constant; it appears to vary more than 5 per cent. The resistance marked "E," in the diagram, seems to be too limited in extent, as a very short motion of the regulator cuts all this resistance in or out, with a consequent noticeable change in the lights.

MR. LINCOLN:—In discussing one paper, the question of expense was referred to, it being said that these systems would be too expensive. It seems to me that the public demands that trains should be electrically lighted, especially well-equipped trains. The fact that these complicated systems outlined here on the board have not only been proposed, but have been actually used, is the very best evidence that expense is not being considered.

Meeting adjourned.

JOHN S. PECK, *Secretary.*

---

DISCUSSION AT SCHENECTADY, MARCH 17, 1903.

*Programme:—*

The meeting was called to order by Past President C. P. Steinmetz. The report of the Committee on Organization was read and adopted, after which the following papers were presented:

1. "Axle Lighting," by E. A. Sperry, read by H. G. Reist.
2. "An Electric Car Lighting System, by W. L. Bliss," read by W. I. Slichter.
3. "An Axle Light System of Train Lighting," by A. J. Farnsworth, read by A. H. Armstrong.
4. "Electric Train Lighting Problems," by George D. Shepardson, read by R. Neil Williams.

Prominent part was taken in the discussion by W. I. Slichter, A H. Armstrong and C. P. Steinmetz. A communication after adjournment was submitted by R. Neil Williams.

MR. A. H. ARMSTRONG:—In the attempt to perfect the car lighting system, I believe many of the inventors have lost sight of the broad issue involved. I think that President Scott has touched on the right thing in proposing the substitution of electric locomotives for steam locomotives. By doing this the train lighting question is solved to the satisfaction of everybody. Many of our larger steam railway systems are seriously considering the electrical equipment of their lines, for local service at least, and in the east this local service extends over a considerable distance. In fact, the eastern travel consists of a series of local runs, and when once the question is taken up, it will not be too much to expect that the limits of local travel of neighboring cities should overlap and form a continuous electrified railway system, say from New York to Albany or from Jersey City to Washington.

All the papers read to-night advocate the car unit system involving some form of axle-driven generator and making each car independent of the composition of the rest of the train. This pre-supposes that the train will be composed of mixed Pullman and day coaches, the latter not being necessarily lighted electrically. Such trains, however, are more or less local in character and will be taken care of within a few years electrically, both for lighting and motive power. The through trains composed of similar units could either be lighted from third rail shoes bearing

on third rail provided for local service, although hauled by steam locomotive, or else by a steam-driven unit in the baggage car or on the locomotive. This system is simpler and gets rid of the many complicated, even if ingenious, mechanisms proposed with the axle driven independent units.

To succeed in railway work a piece of apparatus should be capable of standing considerable abuse, infrequent attention, and should consist of as simple and few parts as possible. A steam turbine driven generator feeding a floating storage battery installed on each car sufficient to give light during times at station when train is broken up for a short time is much simpler, easier to take care of and possesses more promise of ultimate success than the complicated individual systems proposed. Moreover, it is in line with the future progress of steam railroad systems which are bound ultimately to equip their local traffic electrically, at least in the east.

MR. C. P. STEINMETZ:—While the papers read have been very interesting, I think it is to be regretted that no accurate information has been given about the extent to which such systems of axle lighting are being used; nor have we heard how many installations there are of a system of a separate constant speed engine driving a generator in the baggage car or on the locomotive. The phrasing of some of the papers rather leads to the suspicion that the systems described are somewhat experimental and have not yet stood the test of long-continued service.

After all, the amount of power required for train lighting is so insignificant compared with the power of the locomotive, that efficiency appears of very secondary consideration compared with simplicity and reliability. Any system starting from a source of power of such variable speed as that of the car axle necessarily requires a large amount of controlling apparatus to connect and disconnect generator storage batteries, etc., and can not possibly be as reliable as a plain constant speed, constant potential engine-driven generator.

I was very much pleased to find from the discussion that the only objection which fourteen years' experience had brought out against an old friend of mine, the Eickemeyer dynamo driven by a Brotherhood engine, was its large steam consumption. When a reciprocating steam engine running at 800 r.p.m., is left to the tender mercies of a baggage man for fourteen years and develops no other fault than high steam consumption it certainly represents a remarkable performance. Regarding all these here explained ingenious axle-driven systems, I question what would be left of any of them in practical operation under similar conditions.

W. I. SLICHTER:—In the system proposed by Mr. Bliss the voltage of the generator is kept constant at a greatly increased speed by interposing a counter e.m.f. in the shunt field circuit. Thus, we may have three times full load speed, full load voltage, which would mean one-third field excitation, and there would be

a great tendency to spark. To obviate this, the dynamo must be either very large for its purpose or of a special design.

The low voltages used in all these systems is no doubt an aid to the long life of the lamps, since a low voltage lamp of a given candlepower can stand a greater variation in voltage in per cent. than a high voltage lamp.

On a general application of these systems, we know that the direct connected unit is used on one of the trains of the New York Central and the Gould system, in which an axle-driven generator charges alternately two sets of storage batteries, one of which is connected to the lamps while the other is being charged.

---

(COMMUNICATION AFTER ADJOURNMENT OF SCHENECTADY MEETING, BY R. NEIL WILLIAMS.

In reading the papers on Railroad Train Lighting, discussed at the March meeting of the INSTITUTE, I notice that it seems to be generally taken for a foregone conclusion that no system of electric train lighting is possible that does not entail the use of a storage battery. The experience we have had in the past with stationery storage batteries has not been such as to warrant our making them the all-essential feature of a train lighting system, where the continual shaking and jolting must shorten the life and reduce the reliability of the most up-to-date battery.

It is also difficult to see what advantages axle-lighting systems have over the large unit steam dynamo or preferably turbine-dynamo on the locomotive, where it properly belongs. In the former case we have as many units as the train has cars and we have all kinds of difficulties in transmitting our power from locomotive through drawbars to axles and from these to the dynamos, where further complicated devices are required to regulate voltage or speed under widely varying conditions. A simple flexible connection from car to car is certainly cheaper and gives the right power whether train is standing or moving.

Furthermore, the jar from a comparatively small collision would probably be sufficient to demolish any storage battery, whereas, even though all the cars should be completely demolished and only the locomotive left intact, or partly intact, it would be easy to rig up temporary lights from the engine. The following arrangement contains nothing new in the way of engineering features, but at the same time has not been brought out, as far as I know, as a possible and very simple solution of the problem and one which avoids entirely the use of storage battery.

This would be simply to have the cars wired as they are on any electric railroad, but without regulating devices of any description. The tracks would be used for return circuit and power led into the car and from car to car by a flexible coupling, energy being supplied from turbine-dynamo set on the locomotive. This would give light at all times except when the locomotive was uncoupled from the train, which, though occurring frequently is never at any other place than where there are

stations or at least switches and sidings of some kind. If, wherever there is a switch or siding of any kind, in fact at any place where there could ever be any object in the locomotive being uncoupled, a third rail were provided of very modest dimensions and each locomotive as well as each car were provided with a simple shoe, then whether coupled or uncoupled the engine would itself feed the third rail and from it the cars would receive their energy at the same voltage they had been receiving and under exactly the same conditions. There is no apparent reason why cars should be lighted until sometime before the trains are ready to start and then there will always be a locomotive in the neighborhood. Of course, with Pullman sleepers which take on their passengers in the early part of the evening long before the train is ready to leave, it might occur that there was no locomotive in the vicinity. In this case it might be necessary to have a stationary storage battery at such points floating on the third rail, but this would be the exceptional case, and even here the storage battery would not be jolted to pieces. The expense of this third rail, even if it were laid at every switch and siding from New York to San Francisco, and of the one shoe per car and locomotive, would be extremely small, compared with the expense of the storage battery and the divers regulating devices required, if we were to attempt to light all our cars by the axle system.

At this stage of engineering advance in America, it is a poor showing that the railroads make with their flickering gas light and continually reoccurring fires, and it would seem as though the time were ripe for revolutionary changes.

---

DISCUSSION AT DENVER, COLO., FEBRUARY 26, 1903.

The last meeting of this Branch was held on February 26th. Henry L. Doherty presided. Ten visitors and twenty INSTITUTE members attended. Original papers entitled: "From the Earliest Telegraph Down to the Present Time," and "Practical Operation of Duplex and Quadruplex Instruments," were presented by local members. An interesting discussion followed the presentation of the papers.

E. Y. SAYER,
*Secretary.*

---

DISCUSSION AT ST. LOUIS, MO., FEBRUARY 27, 1903.

A meeting of the St. Louis Branch was held at the Engineers' Club, St. Louis, on February 27th. Mr. H. H. Humphrey presided.

The papers on Electric Car-Lighting presented at the New York meeting were read by Messrs. Schwedtman, Fansler and Bausch.

The Discussion was participated in by Messrs. Roach, Schwedtman, Klauder and Moore. Mr. Welz, of the World's Fair Board, gave some interesting observations in regard to European practice in train lighting.

GERARD SWOPE,
*Secretary.*

DISCUSSION AT THE UNIVERSITY OF ILLINOIS, MARCH 7, 1903.

A meeting of this Branch was held at the University of Illinois on March 7th. Prof. W. H. Williams presided. Three members of the INSTITUTE and thirteen students attended. The papers presented at the New York meeting on February 27th. were read by Messrs. Duffy, Williams and Rose. The discussion was participated in by nearly all present, especial reference being made to the prevailing system on Western roads of carrying an isolated plant on a special tender or baggage car, the plant sometimes including boiler capacity enough to heat train.

MORGAN BROOKS,
*Secretary.*

---

DISCUSSION AT THE WESTERN UNIVERSITY OF PENNSYLVANIA, MARCH 12, 1903.

The last meeting of this Branch was held March 12th. at the Western University of Pennsylvania. Mr. Addy presided. The papers presented at the New York meeting of February 27th. were read by Messrs. Dodds, Worcester and Stein.

L. K. LYNN,
*Secretary.*

---

DISCUSSION AT THE OHIO STATE UNIVERSITY, MARCH 12, 1903.

The last meeting of this Branch was held at the Ohio State University, on March 12th. F. R. Kunkle presided. Twenty-eight INSTITUTE members and visitors attended. The INSTITUTE papers on Railway Train Lighting presented at the New York meeting on February 27th. were read by Messrs. Beach, Bostater and Mooney. After the reading there was a general discussion.

F. C. CALDWELL,
*Secretary.*

---

DISCUSSION AT THE UNIVERSITY OF WISCONSIN, MARCH 12, 1903.

A meeting of this Branch was held in the Engineering Building of the University of Wisconsin on March 12th. The papers presented at the New York meeting on Feb. 27th. were abstracted by Mr. E. B. Mueller. A general discussion followed.

G. C. SHAAD,
*Secretary.*

---

DISCUSSION AT THE UNIVERSITY OF MISSOURI, MARCH 14, 1903.

The last meeting of this Branch was held on March 14th at the Engineering Building, University of Missouri. Prof. H. B. Shaw presided. One INSTITUTE member and twenty-five students attended. The papers by Messrs. Bliss, Sperry and Farnsworth were read in abstract by Messrs. Hooke, E. B. Smith and Hess. A general discussion followed.

E. A. BRISCOE,
*Secretary.*

## Discusison at Boston, March 26th, 1903.

A meeting of the Boston Branch was held at the Tech. Union, Boston, March 26th. Dr. Louis Duncan presided. Seventy-five Institute members and seventy-five members of the Massachusetts Institute of Technology Electrical Engineering Society were in attendance.

Preceding the reading of the papers there was an executive business session, at which a permanent organization was formed and the following named officers elected:

Chairman, C. L. Edgar; Secretary, Ralph W. Eaton; Executive Committee, C. L. Edgar, J. W. Welsh, Louis Duncan, A. E. Kennelly and C. B. Burleigh.

Mr. James F. McElroy of Albany, read a paper on "A New System of Axle Lighting." [See April, 1903, Transactions.]

The papers presented by Messrs. Bliss and Farnsworth at the New York meeting on February 27th. were abstracted by Messrs. Welsh and Porter of the M. I. T. Electrical Engineering Society. The discussion was participated in by Messrs. Duncan, Lee, Fleming and McElroy.

Ralph W. Eaton,
*Secretary.*

*A paper read at the 4th Meeting of the Pittsburg Branch American Institute of Electrical Engineers, February 5, 1903.*

# THE ARCOPHONE.

BY R. A. L. SNYDER.

The arcophone or speaking arc is the first successful loud-speaking telephone receiver thus far discovered. The discovery of this property of the electric arc to reproduce speech was first made by Dr. Simon at the University of Erlangen. In the Fall of 1897 he found that by making and breaking the current in a circuit paralleling an arc circuit, sounds corresponding to the make and break were reproduced by the arc. Since that time Dudell and Ruhmer have taken up the subject and added very materially to the results. Dudell shunted the arc with inductance and capacity, and produced the *whistling arc*. By varying the amount of capacity and inductance he could produce a note of any *desired pitch*. Ruhmer, copying Bell's photophone principle, used a searchlight for transmitting the light waves from an arc lamp to a selenium cell—a telephone receiver and battery are placed in series with the selenium cell. By this arrangement, speech can be transmitted for a considerable distance by means of the light waves. The *Electrical World and Engineer* of December 20, 1902, contains an article by Frederick Collins describing how Herr Ruhmer transmitted speech by means of light waves to a distance of 12 miles, and in a very satisfactory manner.

Dr. K. E. Guthe, at the University of Michigan, gave an exhibition of a speaking arc before the University Engineering Society, March 28, 1902. He claims to have discovered that the sound continues a short time after the arc is blown out.

The lamp on exhibition to-night is an ordinary Schuster hot wire arc lamp, working on 110 volts direct current. In series with the lamp is an impedence coil. This impedence coil is shunted by an ordinary solid-back transmitter, and the lamp and

coil are shunted by a condenser. The positive carbon is a special kind, being impregnated with foreign substances to produce a longer and more uniform arc. In the arc formed between ordinary carbons there is a great fall of potential close up to the positive carbon; in the arc formed between impregnated carbons there is a more uniform drop of potential all the way across the arc.

Fig. 1 shows a diagram of the circuit.

I have seen a number of arrangements suggested for the speaking arc circuit, but none with a condenser shunt. The condenser shunt adds very materially to the results. We have tried to make an *alternating current* arc reproduce speech; the results were reasonably good, except that it sounded as if the speech were confused with the notes of a jew's-harp.

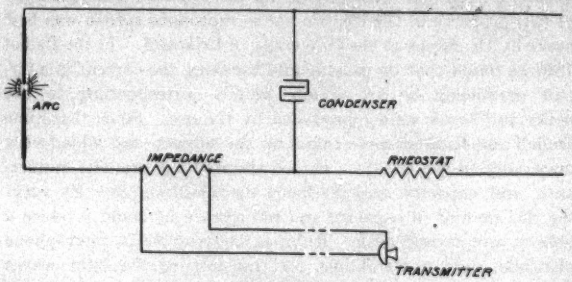



FIGURE #1

Several theories have been advanced as to what causes these sound waves to issue from the arc. The most logical explanation appears to be the one giving the cause as the sudden expansion and contraction of air due to variations in the temperature of the arc.

In speaking into the transmitter the sound waves strike the diaphragm causing, the current to pulsate in the transmitter circuit; and this pulsating current sets up similar pulsations in the arc circuit. The temperature of the arc varies as the *square* of the current passing through it. As the arc is composed principally of carbon-vapor in a high state of molecular vibration, it has a very low specific heat. The temperature of this vapor varies almost *instantly* with the current. When this current is pulsating, the temperature of the arc is raised or lowered corres-

pondingly, and the volume of vapor is increased or diminished in accordance with its temperature. Hence the volume of the vapor increasing and diminishing sets up sound waves in the surrounding air.

After hearing this novelty and knowing how it works, the natural question is as to its use. It may possibly be used in the near future for a single speaker to address great audiences with but little effort. This can be done by the speech waves from a transmitter circuit being impressed upon the field of an arc light generator. All the lamps supplied by this machine will reproduce the speech.

Besides being of use in addressing large audiences and transmitting wireless telephone messages, the value of the arcophone as an advertiser is obvious. Thunder, one of the loudest known sounds, is produced by the electric arc.

## ACCESSIONS TO THE LIBRARY.

The following donations have been made to the Library since the last acknowledgment.

**Bion J. Arnold:**

ARNOLD, B. J. Report on the Engineering and Operating Features of the Chicago Transportation Problem. 2 vols., 8°. Chicago. 1902.

**Brown, C. S. V.**

BROWN, C. S. V., (*editor*). Directory and Statistics of Electric Lighting and Traction Works in Operation or Projected in Great Britain and Ireland. 616 pp., 8°. London 1903.

**Theodore L. De Vinne:**

DE VINNE, T. L. Correct Composition. A Treatise on Spelling, Abbreviations, the Compounding and Division of Words, the Proper Use of Figures, etc. 2d edition. 276 pp., 8°. New York. 1902.

DE VINNE, T. L. Historic Printing Types. A Lecture Read before the Grolier Club of New York, January 25, 1885, with Additions and New Illustrations. 110 pp., 8°. New York. 1886.

DE VINNE, T. L. Invention of Printing. A Collection of Facts and Opinions Descriptive of Early Prints and Playing Cards. The Block-Books of the Fifteenth Century... 2d edition. 557 pp. il. pl., 4°. New York. 1878.

DE VINNE, T. L. Treatise on the Processes of Type-making, the Point System, the Names, Sizes, Styles and Prices of Plain Printing Types. 2d edition. 403 pp., il., 8°. New York. 1902.

DE VINNE, T. L. A Treatise on Title-Pages with Numerous Illustrations in Fac-Simile and Some Observations on the Early and Recent Printing of Books. 485 pp., 8°. New York. 1902.

**Gauthier-Villars:**

Annuaire du Bureau des Longitudes. 16°. Paris. 1903.

**Dr. Cary T. Hutchinson:**

ARLDT, C. Elektrische Kraftübertragung und Kraftverteilung. 386 pp., il., 8°. Berlin. 1901.

ARNOLD, E. Die Ankerwicklungen und Ankerkonstruktionen der Gleichstrom-Dynamomaschinen. 2d edition. 312 pp., 8°. Berlin. 1896.

ARNOLD, E. Constructionstafeln für den Dynamobau. 2 parts. plates. F. Stuttgart. 1899.

AYRTON, W. E. Practical Electricity. 516 pp., 8°. London. 1887.

BENJAMIN, P. The Voltaic Cell. Its Construction and its Capacity. 562 pp., 8°. New York. 1893.

BUCKLEY, W. J. Electric Lighting Plants. Their Cost and Operation. 275 pp., 8°. Chicago. 1894.

CARHART, H. S. Primary Batteries. 193 pp. 8°. Boston. 1896.

CARTER, E. T. Motive Power and Gearing for Electrical Machinery. A Treatise on the Theory and Practice of the Mechanical Equipment of Power Stations for Electric Supply and for Electric Traction. 620 pp., 8°. New York. [pref. 1896.]

**Dr. Cary T. Hutchinson:**—(*Continued.*)

CLARK, L., and SABINE, R. Electrical Tables and Formulæ. 285 pp., 8°. London. 1871.

DUHEM, P. Leçons sur l'Electricité et le Magnétisme. 3 vols., 8°. Paris. 1891–1892.

DU MONCEL, T., and PREECE, W. H. Incandescent Electric Lights, with Particular Reference to the Edison Lamps at the Paris Exhibition. 2d edition. 187 pp., 16°. New York. 1882.

Electrical Society of Cornell University. Proceedings. 1894–1895. Vol. 2, 8°. Ithaca. 1895.

The Electrician Primers. 2 vols., 8°. London. [pref. 1891.]

EWING, J. A. Magnetic Induction in Iron and Other Metals. 351 pp., 8°. London. 1891.

FAIRCHILD, C. B. Street Railways, their Construction, Operation, and Maintenance. . . 472 pp. F. New York. 1892.

FLEMING, J. A. Short Lectures to Electrical Artisans 208 pp., 8°. London. 1886.

FONTAINE, H. Eclairage à l'Electricité. 3d edition. 688 pp., 8°. Paris. 1888.

FOOTE, A. R. Economic Value of Electric Light and Power. 191 pp., 8°. Cincinnati. 1889.

FOSTER, H. A. Central Station Management and Finance. 50 pp., 8°. New York. 1891.

FRANKLIN, W. S., and WILLIAMSON, R. B. The Elements of Alternating Currents. 212 pp., 8°. New York. 1899.

GERARD, E. Leçons sur l'Electricité. 2d edition. 2 vols. 8°. Paris. 1891.

GERARD, E. Leçons sur l'Electricité. 3d edition. 2 vols., 8°. Paris. 1893.

GORDON, J. E. H. Practical Treatise on Electric Lighting. 228 pp., 8°. New York. 1884.

GORE, G. The Art of Electrolytic Separation of Metals, etc. (Theoretical and Practical.) 301 pp., 8°. London. 1890.

GORE, G. Theory and Practice of Electro-Deposition. 132 pp., 8°. London. 1888.

HAUPT, H. Street Railway Motors; with Descriptions and Cost of Plants and Operation of the Various Systems in Use or Proposed for Motive Power on Street Railways. 213 pp., 8°. Philadelphia. 1893.

HEDGES, K. Continental Electric Light Central Stations, with Notes on the Methods in Actual Practice for Distributing Electricity in Towns. 210 pp. F. London. 1892.

HERING, C. Practical Directions for Winding Magnets for Dynamos. 63 pp., 8°. New York. 1887.

HERING, C. Principles of Dynomo-Electric Machines. 279 pp., 8°. New York. 1890.

HERRICK, A. B. Modern Switchboards. 222 pp., F. Philadelphia. 1898.

HOSPITALIER, E. Polyphased Alternating Currents. 84 pp., 8°. London. n.d.

JENKIN, F. Electricity and Magnetism. 9th edition. 391 pp., 8°. London. 1887.

Kalender für Elektrotechniker. 1891, 1895. 12°. München. 1891–1895.

KAPP, G. Electric Transmission of Energy and its Transformation, Subdivision and Distribution. 4th edition. 445 pp., 8°. New York. [pref. 1894.]

**Dr. Cary T. Hutchinson:**—(*Continued.*)

KEMMANN, G. Die Berliner Elektrizitätswerke bis Ende 1896. 270 pp., F. Berlin. 1897.

KEMPE, H. R. A Handbook of Electrical Testing. 4th edition. 551 pp., 8°. London. 1887.

KENNEDY, R. Electrical Distribution by Alternating Currents and Transformers. 60 pp., 8°. London. 1887.

KENNELLY, A. E. Theoretical Elements of Electro-Dynamic Machinery. Vol. 1, 8°. New York. 1893.

KILGOUR, M. H., SWAN, H., and BIGGS, C. H. Electrical Distribution, its Theory and Practice. 424 pp., 8°. London. [1893.]

KOPPEL, A. Transportable und feste Eisenbahnen. 51 p. F. Berlin. 1900.

LAFFARGUE, J. Les Applications Mécaniques de l'Enegie Electrique. 363 pp., 8°. Paris. 1895.

LATIMER, L. H. Incandescent Electric Lighting... 140 pp., 16°. New York. 1890.

LUCE, R. Electric Railways and the Electric Transmission of Power Described in Plain Terms. 108 pp., 8°. Boston. 1886.

MCMILLAN, W. G. Treatise on Electro-metallurgy. 387 pp., 8°. London. 1891.

MAIER, J. Arc and Glow Lamps. A Practical Handbook on Electric Lighting. 375 pp., 8°. London. 1886.

MAXWELL, J. C. Treatise on Electricity and Magnetism. 2d edition. 2 vols., 8°. Oxford. 1881.

MAXWELL, J. C. Traité d'Electricité et de Magnétisme. 2 vols., 8°. Paris. 1885–1889.

MERRILL, E. A. Electric Lighting Specifications. 176 pp., 8°. New York. 1892.

National Electric Light Association. Proceedings. Vol. 15, 8°. New York. 1892.

NIPHER, F. E. Electricity and Magnetism. 426 pp., 8°. St. Louis. 1895.

NOLL, A. How to Wire Buildings. A Manual of the Art of Interior Wiring. 162 pp., 8°. New York. 1893.

OHM, G. S. The Galvanic Circuit Investigated Mathematically. 269 pp., 16°. New York. 1891.

OSTERBERG, M. Synopsis of Current Electrical Literature. 143 pp., 8°. New York. 1896.

PERRY, N. W. Electric Railway Motors. Their Construction, Operation and Maintenance... 238 pp., 12°. New York. 1894.

PLANTÉ, G. Storage of Electrical Energy and Researches in the Effects Created by Currents Combining Quantity with High Tension. 268 pp., 8°. London. 1887.

POINCAIRÉ, H. Electricité et Optique. I. Les Théories de Maxwell et la Théorie Electro-magnétique de la Lumière. 314 pp., 8°. Paris. 1890.

POPE, F. L. Evolution of the Electric Incandescent Lamp. 91 pp., 8°. Elizabeth. 1889.

PREECE, W. H., and MAIER, J. The Telephone. 498 pp , 8°. London. 1889.

PREECE, W. H., and SIVEWRIGHT, J. Telegraphy. 9th edition. 396 pp., 8°. London. 1891.

RAPHAEL, F. C The Localisation of Faults in Electric Light Mains. A Handbook for Central Station Engineers. 184 pp., 8°. New York. [1897.]

**Dr. Cary T. Hutchinson:**—(*Continued.*)

RECKENZAUN, A. Electric Traction on Railways and Tramways. 422 pp., 8°. London. [pref. 1892.]

ROBB, R. Electric Wiring for the Use of Architects, Underwriters, and the Owners of Buildings. 183 pp., 8°. New York. 1896.

RUSSELL S. A. Electric Light Cables and the Distribution of Electricity. 319 pp., 8°. London. 1892.

SALOMONS, SIR D. Complete Hand-Book on the Management of Accumulators. 2d edition. 31 pp., 8°. London. [pref. 1887.]

SALOMONS, SIR D. Electric Light Installations and the Management of Accumulators. 6th edition. 412 pp., 8°. London. 1891.

SPRAGUE, J. T. Electricity, its Theory, Sources and Applications. 2d edition. 650 pp., 8°. London. 1884.

SWINBURNE, J. Practical Electrical Measurement. 155 pp., 8°. London. 1888.

THOMPSON, S. P. Dynamo-Electric Machinery. 408 pp., 8°. London. 1884.

THOMPSON, S. P. Dynamo-Electric Machinery. 2d edition. 527 pp., 8°. London. 1886.

THOMPSON, S. P. Dynamo-Electric Machinery. A Manual for Students of Electrotechnics. 3d edition. 672 pp., 8°. London. 1888.

THOMPSON, S. P. Lectures on the Electromagnet. 287 pp., 8°. New York. 1891.

THOMPSON, S. P. Polyphase Electric Currents and Alternate Current Motors. 261 pp., 8°. London. 1895.

THOMSON, SIR W. Reprint of Papers on Electrostatics and Magnetism. 2d edition. 592 pp., 8°. London. 1884.

THOMSON, SIR W., and TAIT, P. G. Treatise on Natural Philosophy. Vol. 1 pt. 1–2, 8°. Cambridge. 1879—1883.

TREADWELL, A. Storage Battery. A Practical Treatise on the Construction, Theory and Use of Secondary Batteries. 257 pp., 8°. New York. 1898.

TUNZELMANN, G. W. DE. Electricity in Modern Life. 272 pp., 8°. London. [pref. 1889.]

URQUHART, J. W. Electric Ship Lighting; a Handbook on the Practical Fitting and Running of Ships' Electrical Plant... 278 pp., 8°. London. 1892.

VASCHY, A. Traité d'Electricité et de Magnétisme. 2 vols., 8°. Paris. 1890.

WALKER, S. F. Electric Lighting for Marine Engineers; or, How to Light a Ship by the Electric Light and How to Keep the Apparatus in Order. 293 pp., 8°. London. 1892.

WATT, A. Electro-Deposition. A Practical Treatise on the Electrolysis of Gold, Silver, Copper, etc. 600 pp., 8°. London. 1889.

WATT, A. Electro-Metallurgy Practically Treated. 8th edition. 225 pp., 8°. New York. 1891.

WEBB, H. L. The Telephone Hand-Book. 160 pp., 16°. Chicago. 1899.

WELLINGTON, A. M. and others. The Comparative Merits of Various Systems of Car-Lighting, an Investigation of the Comparative Cost, Safety, Light-giving Powers and General Advantages of Oil Lamps, Compressed Gas, Gasoline Carbureters, Electric Lighting, 303 pp., 16°. New York. 1892.

WOLCOTT, T., KENNELLY, A. E., and VARLEY, R. The Electro-Magnet. 2d edition. 127 pp., 8°. [1900.]

**Dr. Cary T. Hutchinson:**—(*Continued.*)

WRIGHT, A. W. American Street Railways; Their Construction Equipment and Maintenance. 200 pp., 8°. Chicago. 1888.

**Wm. G. Lawrence:**

Annual Report. Hudson (Mass.) Municipal Light Board. Hudson 1902.

**The Macmillan Company:**

JACKSON, D. C., and JACKSON, J. P. An Elementary Book on Electricity and Magnetism and Their Applications. 482 pp., 8°. New York. 1902.

**McGraw Publishing Company:**

American Street Railway Investments. 306 pp. F. New York. 1902.

BELL, L. Art of Illumination. 345 pp. il. pl., 8°. New York. 1902.

BELL, L. Power Distribution for Electric Railroads. 3d edition. 303 pp., 8°. New York. [c 1900.]

BOY DE LA TOUR, H. Induction Motor, its Theory and Design, Set Forth by a Practical Method of Calculation. Translated from the French by C. O. Mailloux. 200 pp., 8°. New York. 1903.

Diagrams of Electrical Connections. With Explanatory Text. (pamphlet.) New York. n. d.

DOBBS, A. E. Practical Features of Telephone Work. 134 pp., 12°. New York. 1899.

EMMET, W. LE ROY. Alternating Current Wiring and Distribution. 2d edition. 98 pp., 12°. New York. 1898.

HERING, C. Universal Wiring Computer. 44 pp. 8° New York. 1894

HOPKINSON J. Original Papers on Dynamo Machinery and Allied Subjects. 249 pp., 12°. New York. 1893.

HOUSTON, E. J. Dictionary of Electrical Words, Terms and Phrases. 4th edition. 990 pp., 8°. New York. [c 1898.]

HOUSTON, E. J. Electricity and Magnetism. 2d edition. 318 pp., 12°. New York. [c 1899.]

HOUSTON, E. J. Electric Transmission of Intelligence. 330 pp., 12°. New York. 1893.

HOUSTON, E. J. Pocket Dictionary of Electrical Words, Terms and Phrases. 945 pp., 12°. New York. 1898.

HOUSTON, E. J., and KENNELLY, A. E. Algebra Made Easy. 101 pp., 8°. New York. 1900.

HOUSTON, E. J., and KENNELLY, A. E. Electric Arc Lighting. 2d edition. 437 pp., 12°. New York. [c 1902.]

HOUSTON, E. J., and KENNELLY, A. E. Electric Heating. 290 pp., 12°. New York. 1895.

HOUSTON, E. J., and KENNELLY, A. E. Electric Incandescent Lighting. 2d edition. 508 pp., 12°. New York. [c 1902.]

HOUSTON, E. J., and KENNELLY, A. E. Electric Motor and the Transmission of Power. 377 pp., 12°. New York. 1902.

HOUSTON, E. J., and KENNELLY, A. E. Electric Street Railways. 367 pp., 12°. New York. 1902.

HOUSTON, E. J., and KENNELLY, A. E. Electric Telegraphy. 448 pp., 12°. New York. 1897.

HOUSTON, E. J., and KENNELLY, A. E. Electric Telephone. 2d edition. 453 pp., 12°. New York. [c 1902.]

**McGraw Publishing Company:**—(*Continued.*)

HOUSTON, E. J., and KENNELLY, A. E. Electricity in Electro-Therapeutics. 2d edition. 452 pp., 12°. New York. 1898.

HOUSTON, E. J., and KENNELLY, A. E. Electricity Made Easy by Simple Language and Copious Illustration. 348 pp., 8°. New York. 1900.

HOUSTON, E. J., and KENNELLY, A. E. Electro-Dynamic Machinery for Continuous Currents. 331 pp., 8°. New York. 1896.

HOUSTON, E. J., and KENNELLY, A. E. Interpretation of Mathematical Formulæ. 225 pp., 8°. New York. 1900.

HOUSTON, E. J., and KENNELLY, A. E. Magnetism. 294 pp., 12°. New York. 1896.

HOUSTON, E. J., and KENNELLY, A. E. Recent Types of Dynamo-Electric Machinery. 612 pp., 8°. New York. 1900.

LYNDON, L. Storage Battery Engineering. 382 pp. il., 8°. New York. 1903.

MERRILL, E. A. (*comp.*) Reference Book of Tables and Formulæ for Electric Railway Engineers. 2d edition. 128 pp., 16°. New York. 1897.

MEYER, H C. Steam Power Plants, their Design and Construction 159 pp., pl., 8°. New York. 1903.

Portraits of Founders of Electrical Science. From Gilbert to Henry. (pamphlet.) New York.

PRATT, M. D., and ALDEN, C. A. Street Railway Roadbed. 135 pp., 8°. New York. 1898.

**Col. Saml. Reber, U. S. A.:**

REBER, S. Handbook of Telephones of the Signal Corps, U. S. Army. 66 pp., il., 8°. Washington. 1903.

**Wm. A. Rosenbaum:**

CROSWELL, S. G. A Treatise on the Law Relating to Electricity. 765 pp., 4°. Boston. 1895.

FOOTE, A. R., and EVERETT, C. E. Economic Legislation of all the States. The Law of Incorporated Companies Operating under Municipal Franchises... 3 vols., 4°. Cincinnati. 1892—1893.

**U. S. Coast and Geodetic Survey:**

U. S. Magnetic Declination Tables for 1902. 405 p., Q. Washington. 1902.

**D. Van Nostrand Company:**

ABBOTT, A. V. Electrical Transmission of Energy. 585 pp., 8°. New York. 1900.

ARNOLD, E. Armature Windings of Direct Current Dynamos. 124 pp., 8°. New York. 1902.

ATKINSON, A. A. Electrical and Magnetic Calculations... 310 pp., 12°. New York. 1902.

ATKINSON, P. Elements of Dynamic Electricity and Magnetism. 405 pp., 8°. New York. 1895.

ATKINSON, P. Elements of Electric Lighting, Including Electric Generation, Measurement, Storage and Distribution. 10th edition. 275 pp., 8°. New York. 1901.

ATKINSON, P. Power Transmitted by Electricity and Applied by the Electric Motor, Including Electric Railway Construction. 239 pp., 8°. New York. 1900.

GIBBS, W. E. Lighting by Acetylene, Generators, Burners and Electric Furnaces. 2d edition. 161 pp., 8°. New York. 1899.

**D. Van Nostrand Company:**—(*Continued.*)

KENNELLY, A. E. Theoretical Elements of Electro-dynamic Machinery. Vol. 1, 8°. New York. 1893.

PALAZ, A. Treatise on Industrial Photometry, with Special Application to Electric Lighting. 2d edition. 324 pp., 8° New York. 1896.

PERRINE, F. A. C. Conductors for Electrical Distribution; their Materials and Manufacture, the Calculation of Circuits, Pole-Line Construction, Underground Working, and Other Uses. 287 pp., il. pl., 8°. New York. 1903.

SHELDON, S., and MASON, H. Dynamo Electric Machinery, its Construction, Design and Operation. Vol. 2, 8°. New York. 1902.

SWOOPE, C. W. Lessons in Practical Electricity, Principles, Experiments and Arithmetical Problems... 462 pp., 8°. New York. 1903.

**J. M. Wakeman:**

DAVIS, D. Manual of Magnetism. 13th edition. 322 pp., il., 8°. Boston. 1869.

**Dr. Leonard Waldo:**

SIEMENS, C. W. Scientific Works. 3 vols., 8°. London. 1889.

**W. D. Weaver:**

ALLEN, J. T. (*comp.*). Supplement to the Digest of United States Automobile Patents, July, 1899, to January, 1902. 1461 pp. Q. Washington. [1902.]

ANGO, A. Les Enregistreurs Météorologiques. pp. 29–39 [pamphlet.] Paris. 1882.

Armengaud and Vanoni, L. Visite à l'Exposition Internationale d'Electricité de Vienne 1883. 38 p. [pamphlet.] Paris. 1883.

ARMENGAUD and others. L'Electricité et ses Applications. 174 pp., il. [pamphlet.] Paris. 1881.

BANDSEPT, A. Les Accumulateurs Electriques et la Mécanique de l'Electrolyse. 82 pp. [pamphlet]. Bruxelles. 1884.

BENHAM, C. E. William Gilbert of Colchester. A Sketch of his Magnetic Philosophy. 96 pp., 16°. Colchester. 1902.

BENNETT, A. R. Telephone Systems of the Continent of Europe. 436 pp., 8°. London. 1895.

BIGGS, C. H. W. and others. Practical Electrical Engineering. A Complete Treatise on the Construction and Management of Electrical Apparatus as Used in Electric Lighting and the Electric Transmission of Power. 2 vols. in 1. F. London. [1890-1892.]

BONEL, A. L'Electricité à l'Exposition de Bordeaux 1882. 59 pp., il. [pamphlet.] Bordeaux. 1882.

BOULARD, J. Production et Applications de l'Electricité... 156 pp., il. [pamphlet.] Paris. 1882.

BRACKETT, C. F., and others. Electricity in Daily Life. A Popular Account of the Applications of Electricity to Every Day Uses. 288 pp., 8°. New York. 1890.

CHALON, P. F. Le Tirage des Mines par l'Electricité. 276 pp., 12°. Paris. 1888.

CLARK, D. K. Tramways, Their Construction and Working. Embracing a Comprehensive History of the System... 2d edition. 758 pp., 8°. New York. 1894.

CONDORCET. Eloge de M Franklin... 42 pp. [pamphlet.] Paris. 1791.

COX, F. P. Continuous-Current Dynamos and Motors. Their Theory, Design and Testing. 271 pp., 8°. New York. 1893.

**W D. Weaver:**—(*Continued.*)

CROSSMAN. Applications de l'Electricité au Matériel des Chemins de Fer. 117 pp., il. [pamphlet.] Paris. 1882.

DICKERSON, E. N. Joseph Henry and the Magnetic Telegraph. An Address Delivered at Princeton College, June 16, 1885. 65 pp., 8°. New York. 1885.

Electricité à l'Exposition Internationale et Coloniale d'Amsterdam de 1883. 44 pp. [pamphlet.] Bruxelles. 1883.

FICHET, A. Les Téléphones. pp. 20–28, il. [pamphlet.] Paris. 1882.

FLEMING, J. A. Magnets and Electric Currents. An Elementary Treatise for the Use of Electrical Artisans and Science Teachers. 408 pp., 8°. London. 1898.

GERARD, E. Electricity and Magnetism. 392 pp., 8°. New York. 1897.

GERARD, E. Mesures Electriques. 457 pp., 8°. Paris. 1896.

GILBERT, W. On the Loadstone and Magnetic Bodies, and on the Great Magnet, the Earth. Translated by P. F. Mottelay. 368 pp., 8°. New York. 1893.

GORDON, J. E. H. Practical Treatise on Electric Lighting. 228 pp., 8°. London. 1884.

GRAFFIGNY, H. DE. L'Ingénieur Electricien. Guide Pratique de la Construction et du Montage de tous les Appareils Electriques. 4th edition. 311 pp. 12°. Paris. [1888.]

HERING, C. Electricity at the Paris Exposition of 1889. 250 pp., 8°. New York. 1893.

HERING, C. Principles of Dynamo-Electric Machines and Practical Directions for Designing and Constructing Dynamos. 279 pp., 12°. New York. 1890.

HERING, C. (*comp.*) Recent Progress in Electric Railways. Being a Summary of Current Periodical Literature Relating to Electric Railway Construction, Operation, etc. 389 pp., 12°. New York. 1892.

HIGGINS, E. E. Street Railway Investments. 102 pp., 8°. New York. 1895.

HOUSTON, E. J. Electricity One Hundred Years Ago and To-Day. 199 pp., 8°. New York. 1894.

LE CHATELIER, H., and BOUDOUARD, O. High-Temperature Measurements. Translated by G. K. Burgess. 230 pp., il., 8°. New York. 1901.

L'INVENTION. Journal mensuel de la Proprieté Industrielle. 12 vols. 1852–1854, 1857–1866, 8°. Paris, 1852–1866.

This publication succeeded a similar journal which had been founded about 1844. Short briefs are given in the earlier volumes of all French and Belgian patents; subsequently, extended accounts of selected new inventions appear with articles on technical subjects and on French and foreign patent practice, etc.

JACQUEZ, E. Dictionnaire d'Electricité et de Magnétisme. 281 pp., 8°. Paris. 1883.

JAPING, E. Le Transport de la Force par l'Electricité. 341 pp., 8° [unbound]. Paris. 1885

KAPP, G. Alternating Currents of Electricity. Their Generation, Measurement, Distribution and Application. 166 pp., 12°. New York. 1893.

KAPP, G. Electric Transmission of Energy, and its Transformation, Subdivision and Distribution. 331 pp., 8°. London. 1886.

KAPP, G. Electric Transmission of Energy, and its Transformation, Subdivision and Distribution. 2d edition. 348 pp., 8°. London. 1890.

**W. D. Weaver:**—(*Continued.*)

KINGDON, J. A. Applied Magnetism. An Introduction to the Design of Electromagnetic Apparatus. 292 pp., 8°. London. [1896.]

LAURIOL, J. Transport Electrique de la Force. Les Expériences de Creil au Point de Vue Pratique... 80 pp. [pamphlet.] Paris. 1886.

LEBLOND, H. Electricité Expérimentale et Pratique. Vol. 2, 8°. [unbound.] Paris. 1890.

LYONS, T. A. The Magnetism of Iron and Steel Ships. 122 pp., 8°. Washington. 1884. (Naval Professional Papers, No 17).

MAN, A. Is Electricity Energy or Only Matter. 57 pp., [pamphlet.] Brooklyn. 1893.

MARIÉ, G. Les Régulateurs dans les Distributions d'Electricité, 104 pp., 8° [unbound]. Paris. 1888

MONMERQUÉ, A. Controle des Installations Electriques au Point de Vue de la Sécurité. 494 pp., 8°. Paris. 1896.

MONNIER, D. Electricité Industrielle. Production et Applications. 553 pp., 4°. Paris. 1889.

MONTAUD, B. DE. L'Accumulateur Employé comme Transformateur-Distributeur à Courants Continus dans les Stations Centrales Electriques. 44 pp. [pamphlet.] Paris. 1888.

MONTPELLIER, J. A. Les Accumulateurs Electriques. Montage, Installation, Conduite, Entretien. 224 pp., 8°. [unbound]. Paris. 1896.

MONTPELLIER, J. A., and FOURNIER, G. Les Installations d'Eclairage Electrique. 536 pp., 8°. [unbound]. Paris. 1890.

MORROW, J. T., and REID, T. Arithmetic of Magnetism and Electricity. 145 pp., 12°. Lynn. 1893

SIEMENS, WERNER, VON. Personal Recollections. Translated by W. C. Coupland. 416 pp., por 8°. New York. 1893.

NANSOUTY, M. DE and ANDRA, R., Exposition des Ministères de la Guerre et de la Marine. Exposition Internationale de l'Electricité, 1881. 19 pp., il. [pamphlet]. Paris. 1882.

OUDIN, M. A. Standard Polyphase Apparatus and Systems. 2d edition. 249 pp., 8°. New York. 1900.

PELLETIER, A. L., and D'AUGE, T. La Pose et l'Entretien des Sonneries Electriques Mises à la Portée de Tout le Monde. 72 pp., il. [pamphlet.] Paris. 1880.

PICOU, R. V. Les Lampes Electriques. 75 pp., il. [pamphlet.] Paris. 1882

POPE, F. L. Index of Patents Relating to Electricity and Magnetism. Their Generation and Applications. Vol. 1. 1790–1870 [pamphlet.] Elizabeth. 1879.

PRESCOTT, G. B. Speaking Telephone, Electric Light, and other Recent Electrical Inventions. 616., 8°. New York, 1879.

RAM, G. S. The Incandescent Lamp and its Manufacture. 218 pp., 8° London. 1893.

REYNIER, E. La Traction Electrique par Accumulateurs Appliquée aux Tramcars de Paris. 29 pp., pl. [pamphlet]. Paris. 1883.

ROBB, R. Electric Wiring for the Use of Architects, Underwriters and the Owners of Buildings. 183 pp., 8°. New York. 1896.

ROUTIN, J. L. Notice sur l'Alternateur, Compound Système Hutin et Leblanc. Etude sur les Transformateurs Statiques (Brevets A. Grammont.) 64 pp., 8°. [unbound]. Paris. 1900.

SCHOENTJES, H. Les Grandeurs Electriques et leurs Unités. 2d edition. 120 pp., il. [pamphlet.] Paris. 1884.

**W. D. Weaver:**—(*Continued.*)

UPPENBORN, F. History of the Transformer. 60 pp. [pamphlet]. London. 1889.

VIVAREZ, H. Construction des Réseaux Electriques Aériens en Fils de Bronze Silicieux Lignes Télégraphiques Téléphoniques, Transport de Force Lumière Electrique. 2d edition. 175 pp., 8°. [unbound]. Paris 1885.

**Dr. Schuyler Skaats Wheeler:**

ABRIA. Rapport sur l'Eloge de Romans. pp. 441–518 [pamphlet]. n.t.p.

ADAMS, G. Essay on Electricity. XVI. + 367 pp., 8°. London, 1784.

BOUDIN. De la Foudre Considérée au Point de Vue de l'Histoire. de la Médecine Légale, et de l'Hygiène Publique. 50 pp. [pamphlet], Pairs. 1855.

BOUDIN. Histoire de la Foudre et des Paratonnerres. 57 pp. [pamphlet]. Paris. 1855.

BOUDIN. Histoire Physique et Médicale de la Foudre, et ses Effets sur l'Homme, les Animaux, les Plantes, les Edifices, les Navires. 31 pp. [pamphlet]. Paris. 1854.

BOYLE, R. Works. 5 vols. F. London. 1744.

CLÉMENT-MULLET, J. J. Sur les Bélemnites, les Pierres de Foudre et les Aérolithes. 25 pp. [pamphlet]. Troyes. 1840.

DU MONCEL, T. Théorie des Eclairs. 46 pp. [pamphlet]. Cherbourg. 1854.

L'Électricité Soumise à un Nouvel Examen, dans différentes Lettres addressées à M. l'Abbé Nollet par l'Auteur du Dictionnaire de Physique. XLVII.+ 286 pp., 12°. Avignon. 1768.

Epitome of Electricity & Galvanism, By Two GENTLEMEN OF PHILADELPHIA. v.p., 8°. Philadelphia. 1809.

FERGUSON, J. Introduction to Electricity. 2d edition. 140 pp., 8°. London. 1775.

FERGUSON, J. Introduction to Electricity. 3d edition. 140 pp., 8°. London. 1778.

GALE, T. Electricity, or Ethereal Fire, Considered. 276 pp., 12°. Troy. 1802.

GALLITZIN, D. A. Sendschreiben an die kaiserliche Akademie der Wissenschaften zu St. Petersburg über einige Gegenstände der Electricität. 56 pp. [pamphlet]. Münster. 1780.

HARRIS, W. S. Protection from Lightning. 10 pp. [pamphlet.] n.p. 1842.

HARRIS, W. S. Record of Philosophical Papers and Other Scientific Works. 7 pp. [pamphlet.] Plymouth. n.d.

HARRIS, W. S. Remarkable Instances of the Protection of Certain Ships...from the Destructive Effects of Lightning. v.p. [pamphlet.] London. 1847.

IZARN, J. Manuel du Galvanisme. 304 pp., 8°. Paris. 1805.

LOVETT, R. Sir Isaac Newton's Aether Realized; or, The Second Part of the Subtil Medium Proved, and Electrically Made Useful. 77 pp., 8°. London. 1759.

LOVETT, R. Letter to the Authors of the Monthly Review; or, a Reply to their Animadversions on a Phamplet...intitlued, The Reviewers Review'd. Relative to the Doctrine of Electricity. 27 pp., 8°. London. 1761.

LOVETT, R. The Reviewers Review'd; or, The Bush-Fighters Exploded; Being a Relpy to the Animadversions...Aether Realized ... 41 pp., 8°. Worcester. 1760.

**Dr. Schuyler Skaats Wheeler:**—(*Continued.*)

LOVETT, R. The Subtil Medium Prov'd: or, That Wonderful Power of Nature... called sometimes Aether, but oftener Elementary Fire... 152 pp., 8°. London. 1756.

MONTIGNY, C. Note sur la Vitesse du Bruit du Tonnerre. 13 pp. [pamphlet]. [Bruxelles.] n.d.

Notice Historique sur le Tonnerre et les Eclairs. 54 pp., [pamphlet]. n.t.p.

PELTIER. Note sur les Phénomènes que peuvent présenter les Arbres Soumis à l'Influence d'un Nuage Charge d'une Puissante Tension Electricité. 7 pp. [pamphlet]. Paris. 1846.

RICHARDOT, C. Nouveau Appareils contre les Dangers de la Foudre et le Fléau de la Grêle; ou, Système Général de Paragréles. 2d edition. 44 pp. [pamphlet]. Paris. 1825.

R [ICHARDOT], C. Nouveau Appareils contre les Dangers de la Foudre; ou, les Paratonnerres Popularisés. 58 pp. [pamphlet]. Paris. 1846.

SAINT-AGOBARD. De la Grêle et du Tonnerre. 55 pp. [pamphlet]. Lyon. 1841.

SIGAUD DE LA FOND. Traité de l'Electricité. XXX.+416 pp., 12°. Paris. 1771.

THURY, H. DE. De l'Influence des Arbres sur la Foudre et ses Effets... 27 pp., [pamphlet]. Paris. 1838.

TOALDO, J. Mémoires sur les Conducteurs pour Préserver les Edifices de la Foudre. X.+241 pp. [pamphlet]. Strasbourg. 1779.

**John Wiley and Sons:**

TRAUTWINE, J. C. Civil Engineer's Pocket-Book. 18th edition. 1079 pp., 12°. New York. 1902.

**Townsend Wolcott:**

ATKINSON, P. Electric Transformation of Power and its Application by the Electric Motor, Including Electric Railway Construction. 244 pp., il., 8°. New York. 1893.

CROCKER, F. B. Electric Lighting... Vol. 2. Distributing System and Lamps. 505 pp., il., 8°. New York. 1901.

Electrical Catechism, 533 Plain Answers to 533 Practical Questions about Electrical Apparatus, Compiled from the Regular Issues of Power. 210 pp., il., 8°. New York. 1902.

GUNSAULUS, F. W., (*editor.*) Modern Engineering Practice. 10 vols., 8°. Chicago. 1902.

LYONS, T. A. Treatise on Electromagnetic Phenomena and on the Compass and its Deviations Aboard Ship. Mathematical, Theoretical and Practical. Vol. 1, il., 8°. New York. 1901.

NORRIE, H. S. Electric Gas Lighting, How to Install Electric Gas Igniting Apparatus, Including the Jump Spark and Multiple Systems for use in Houses, etc. 101 pp., il., 12°. New York. 1901.

PERRY, N. W. Electric Railway Motors, Their Construction, Operation and Maintenance... 238 pp., il., 12°. New York. 1896.

# SCIENCE ABSTRACTS.

**Section A, Physics.** **Section B, Engineering.**

Issued monthly under the direction of

## The Institution of Electrical Engineers, London

...and the...

## Physical Society of London.

With the endorsement of the American Institute of Electrical Engineers

The subscription price including the Annual Index is $4.50 for either section separately, $7.50 for the two together.

Members or Associates of the American Institute of Electrical Engineers can, by special arrangement, subscribe through the Secretary of the Institute on the reduced terms of $3.50 for either section separately, or $5.00 for the two together, posted to members' addresses. More than 150 publications, including Society Transactions and other periodical publications, both scientific and technical, appearing in Great Britain, The United States, Canada, France, Germany, Austria, Russia, Italy, Hungary, Switzerland, Holland, Belgium, Norway, Sweden, Denmark, Australia and New Zealand, are regularly abstracted.

The contents of the two sections are as follows:

**Section A.** Light, including Photography; Heat; Sound; Electricity and Magnetism; Chemical Physics and Electro-Chemistry; General Physics; Meteorology and Terrestrial Physics; Physical Astronomy.

**Section B.** Steam Plant, Gas and Oil Engines; Automobiles; Oil-engine driven ships and launches; Balloons and Airships: General Electrical Engineering, including Industrial Electro-Chemistry; Electric Generators; Motors and Transformers; Electrical Distribution, Traction and Lighting; Telegraphy and Telephony.

"Science Abstracts" has been founded and carried on with the aid of annual grants from the Institution of Electrical Engineers, London, The Institution of Civil Engineers, London, and the Physical Society of London; and of initial grants from the Royal Society, London, and the British Association for the Advancement of Science. The whole of the funds at the disposal of the Committee responsible for the publication are expended in its production, extension and improvement; the publication being conducted, not for profit, but with the object of providing Engineers and Physicists with as complete a record as possible of progress both in practical engineering and, in the pure sciences which form its foundation.

The Publishers and Advertising Agents are:

THE FEILDEN PUBLISHING CO., LTD.

104 HIGH HOLBORN, LONDON, W. C.

A specimen copy of either section can be obtained on application, inclosing stamps of value 15 cents, to R. W. Pope, 95 Liberty Street.

G. W. de TUNZELMANN, Consulting Engineer,

82 VICTORIA STREET, LONDON, S. W.

3533

# THE ELECTRIC STORAGE BATTERY CO.,

PHILADELPHIA.

Manufacturer of the

## "Chloride Accumulator

3533

FOR

Central Station Lighting and Power Plants,
Isolated Lighting and Power,
Electric Railway Power and Sub Stations,
Telegraph, Fire Alarm, Telephone, etc.

Send for Descriptive Bulletins and Price Lists.

SALES OFFICES:

NEW YORK. 100 Broadway — BOSTON. 60 State St. — CHICAGO. Marquette Bldg. — BALTIMORE. Continental Trust Building. — ST. LOUIS. Wainwright Bldg.

CLEVELAND. New England Bldg. — SAN FRANCISCO. Nevada Block. — PHILADELPHIA. Allegheny Av. & 19th St. — DETROIT. Michigan Electric Co.

HAVANA, CUBA. G. F. Greenwood, Mgr., 34 Empedrado Street.

# McINTOSH, SEYMOUR & CO.

## AUBURN, N. Y.

—BUILDERS OF—

## Engines FOR ALL Electrical Purposes.

# POLYTECHNIC INSTITUTE OF BROOKLYN

New York City.

HENRY SANGER SNOW, LL.D., President.

6748

ELECTRICAL ENGINEERING COURSE.

A four years' course of study leading to the degree of Electrical Engineer, and offering exceptional facilities for acquiring a thorough practical as well as theoretical knowledge of the science. By employing the splendid facilities of New York City itself as well as those of the Institute, the student is prepared to undertake at once the mastery of electrical problems and the control of electrical industries.

Graduates are everywhere occupying with honor positions of the gravest trust, many of which were obtained for them by the Institute bureau in no section of the country are practical electrical engineers in greater demand than in New York.

ADVANTAGES OF SITUATION.

Students of the POLYTECHNIC INSTITUTE have placed at their disposal every advantage of the metropolis, itself a laboratory of invaluable utility. The variety and scope of practical operations open to inspection is of especial service; the kilowatt capacity of the city's central stations is greater than that of any other city in the world, Niagara Falls not excepted. Here may be studied the most modern methods for electric lighting, and for the generation, transmission, distribution and utilization of electric power.

For information apply to **Samuel Sheldon, A. M., Ph. D.**

# SPRAGUE
## ELECTRIC COMPANY
MANUFACTURERS OF
**High Grade Electric Apparatus**
General Offices: 527-531 West 34th Street, New York.

# WESTON
STANDARD
PORTABLE
DIRECT READING

## Voltmeters
—AND—
## Ammeters

FOR ALTERNATING AND DIRECT CURRENT CIRCUITS.

The only STANDARD PORTABLE instruments of the type deserving this name.

Weston Standard Portable, Direct Reading Voltmeter.

Our Portable Instruments are recognized as the **Standard** the world over. The Semy Portable Laboratory Standards are still better. Our **Station Voltmeters** and **Ammeters** are unsurpassed in point of extreme accuracy and lowest consumption of energy.

## Weston Electrical Instrument Co.

BERLIN: European Weston Electrical Instrument Co., No. 88 Ritterstrasse.
LONDON: Elliott Bros., Century Works, Lewisham.
PARIS E. H. Cadiot, 12 Rue St. Georges.

Waverly Park,
Newark, N. J.

NEW YORK OFFICE, 74 Cortlandt Street.

SACHS TRADE NOARK MARK FUSE

## Protective Devices
*FOR ANY VOLTAGE—110 to 20,000*

Do Not Arc But Indicate

Main Cut Out. Subway Boxes.
Branch Cut Out. Fuse Plugs, etc.

*Send for complete set of "NOARK" FUSE BULLETINS.*

INSULATION
*Moulded Mica.*
*Vulcabeston.*
*Monarch.*

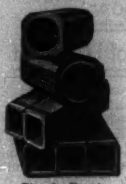
LINE MATERIAL

Send for "Electrical Supplies" Catalogue.

NEW YORK
MILWAUKEE
CHICAGO
ST. LOUIS
BOSTON

H. W. JOHNS-MANVILLE CO.

PHILADELPHIA
CLEVELAND
PITTSBURG
NEW ORLEANS
LONDON



Single Duct
Multiple Duct

# STANDARD VITRIFIED CONDUIT CO.

*39-41 Cortlandt St., New York*

**Largest Factories in the World**

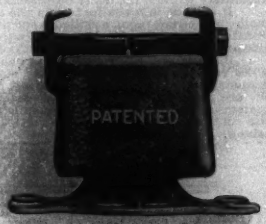
MANHATTAN
THIRD RAIL INSULATOR

**Mersey Railway, London**

**Scioto Valley R. R., Ohio**

**Manhattan Elevated R. R., N. Y.**

**Carnegie Steel Co.**




**Send For Our New Catalogue**


## THE INSTITUTE BADGE.

The Council has authorized the sale of Badges of the new design at the following prices, for the different styles.

| | |
|---|---|
| Vest Pin, | $3.00 |
| Scarf Pin, | 3.00 |
| Watch Charm, | 3.00 |
| Lapel Button, | 4.00 |

All of the above patterns are of solid 14K gold and finely finished. The enamel is blue for Members, and maroon for Associates. One dollar will be allowed for the old badge when returned. The initials or full name as desired, will be engraved on the back together with serial Number.

Address,

**R. W. POPE,** *Secretary.*
95 Liberty Street, New York.

## Every Engineer Should Know

## Bituminized Fiber Electrolysis-Proof Conduit

**(PATENTED.)**

It is the best in the world for underground electric work under all possible conditions, whether the system of ducts be for power, lighting, railway, telephone or telegraph circuits. For five years the truth of this has been proved by the installation of millions of feet in many cities between Chicago and the Pacific Slope.

Bituminized Fiber Conduit is the cheapest, the strongest, the lightest and the most easily laid conduit on the market. It is non-corrosive, non-abrasive, non-decayable, electrolysis-proof, a perfect insulator, water, gas and air tight, and absolutely without the many objectionable features of all other forms of conduit.

It is made in seven-foot units the alignment is perfect and practically automatic, it does not require skilled labor to lay, and is the most rapid and cheapest installation known. All units are slip-jointed and lathe-turned on a slight bevel. Each unit is uniform to the hundredth of an inch.

Bituminized Fiber Conduit is guaranteed against breakdowns for 40,000 to 50,000 volts service. We stock four standard sizes—2 inches to 3¼ inches inside diameter—all in seven-foot lengths, and make to order from 1¼ to 10 inch diameters. We are pleased to give complete details and estimates of entire underground systems of distribution under all conditions. Our statements are no stronger than our conduit—both will stand the test. Our illustrated catalog is yours for the asking. Suppose you write to-day.

## AMERICAN CONDUIT COMPANY

| PHILADELPHIA | CHICAGO | LOS ANGELES |
|---|---|---|
| *720 Arcade Bldg.* | *822 Manhattan Bldg.* | *336 Marcy St.* |

# ALL INTERESTED

whether members or not, should send at once for the revised

## INSTITUTE CATALOGUE

(To January 1, 1903.)

Members and Associates are entitled to this publication gratis

To non-members

PRICE 50 CENTS

**American Institute of Electrical Engineers**

RALPH W. POPE, Secretary

95 Liberty Street, New York

**BION J. ARNOLD**
Member A. I. E. E.
CONSULTING ELECTRICAL ENGINEER.
Suite 1539 Marquette Bldg., Chicago.
711 Transit Bldg., New York.

**MAX OSTERBERG, E.E., A.M.**
Member A. I. E. E.
CONSULTING ELECTRICAL AND MECHANICAL ENGINEER.
11 Broadway, New York.

**CHARLES K. STEARNS**
Member A. I. E. E.-A. S. M. E.
ELECTRIC RAILWAYS.
LIGHTING AND POWER PLANTS.
LONG DISTANCE TRANSACTIONS.
93 Federal Street, Boston, Mass.

**W. S. BARSTOW**
Member A. I. E. E.
CONSULTING ELECTRICAL AND MECHANICAL ENGINEER,
11 BROADWAY, NEW YORK.
Periodical and Special Reports on Electrical Properties.
Plans, Specifications and Supervision of Installation.
Telephone, 4671 Broad.

**WM. R. C. CORSON,**
CONSULTING ENGINEER.
Ass. Mem. A. I. E. E. Hartford, Conn.
Electric Lighting and Power Plants.
Factory Transmissions.
Investigations of electrolytic action on underground structures.
Electric Machine Design.
Laboratory Experiments and Tests.

PATENT EXPERT.
**James Hamilton, M.E., LL.D.**
COUNSELLOR AT LAW,
West Point, 1890: M.E., Cornell University.
Rooms 129-130
Washington Loan & Trust Building,
cor. Ninth & F Streets., N. W.,
Washington, D. C.

**W. B. VANSIZE**
Member A. I. E. E.
PATENTS AND PATENT LITIGATION.
Postal Telegraph Building,
253 Broadway, New York.

**MODELS, EXPERIMENTAL WORK, SUPPLIES.**
MANUFACTURERS' AND INVENTORS' ELECTRIC CO.,
Store, 82 & 84 Nassau Street,
Factory, 96 & 98 Fulton Street,
New York.
"WHERE THE FAN GOES 'ROUND."

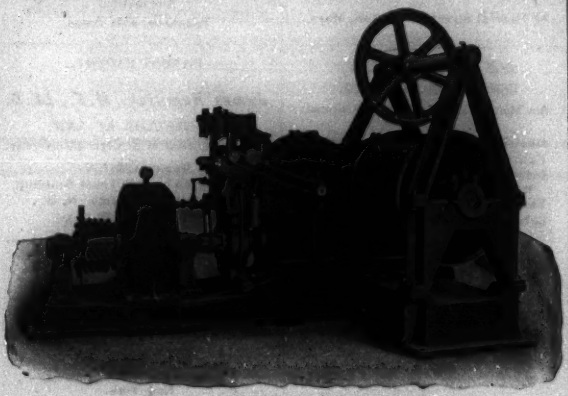
DESIGN OF DYNAMOS
IS THE NEW BOOK BY S. P. THOMPSON.
With Colored and Folding Plates.
250 pages. Price, $3.50.
Send for full description.
PUBLISHERS
SPON & CHAMBERLAIN, 123 LIBERTY ST., NEW YORK.

674

## "NEW STANDARD" ELECTRIC ELEVATORS

**Among Many Installations of Our New Types Are:**

White House, Washington, D.C.
Washington Monument, Washington, D.C.
Home Savings Bank, Washington, D.C.
New York Edison Co.
R. Hoe & Co. Building, N. Y.
Huyler Bros. Building, N. Y.
Café Martin, N. Y.
First Church of Christ (Sci.), New York.
W. W. & T. M. Hall (8 residences), New York.
Library of Congress, Washington, D. C.
Washington Public Library, Washington, D. C.
Metropolitan Opera House, N. Y.
Dunn Building, New York.
Tide-Water Building, New York.
Knox Building, New York.
Amos F. Eno Building, N. Y.
Crocker-Wheeler Co., Ampere, N. J.
Toronto Hotel, (8 elevators), Toronto, Can.
Minneapolis Tribune, Minneapolis, Minn.



We will be pleased to Mail
Bulletins relative to our various types of Elevators and Automatic Controllers.

**WE MAKE A SPECIALTY**
Of Automatically Controlled Elevators for Residences, Freight and Passenger Duty.

## Marine Engine & Machine Co.

*SALES OFFICE:* 1125 Broadway, New York.
*WORKS:* Harrison, New Jersey.

4288

**JUST PUBLISHED**

8vo. Cloth, 287 Pages, Illustrated.

**Price, $3.50 Net.**

Postage, 25 Cents.

# CONDUCTORS

FOR

# Electrical Distribution

**Their Materials and Manufacture, The Calculation of Circuits, Pole Line Construction, Underground Work, and other uses**

By F. A. C. Perrine, A.M., D.Sc.

*ormerly Professor of Electrical Engineering, Leland Stanford, Jr., University. Member American Institute Electrical Engineers.*

CONTENTS.

Conductor Materials. Alloyed Conductors. The Manufacture of Wire. Wire Finishing. Wire Insulation. Cables. Calculation of Circuits. Kelvin's Law of Economy in Conductors. Multiple Arc Distribution. Alternating Current Calculation. Overhead Lines. The Pole Line. Line Insulators. Underground Conductors. Index.

**D. VAN NOSTRAND COMPANY,**

PUBLISHERS AND BOOKSELLERS,

23 Murray and 27 Warren Streets, NEW YORK.

# I-T-E

## CIRCUIT BREAKERS

for 750 volts, and under all capacities, made in single, double, triple and quadruple pole, separately acting or rigidly connected arms.

Multi-voltage problems receive special attention.

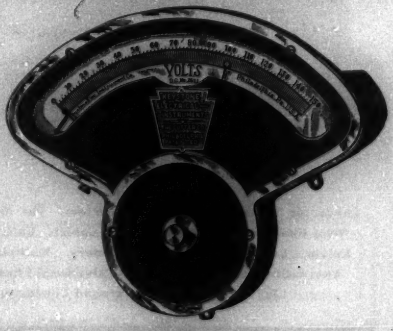
# KEYSTONE MEASURING INSTRUMENTS

Portable and Switchboard Types.

As accurate as a chronometer, strictly "dead beat."

High grade in every particular.

Catalogues upon request.




**Have you a copy of "Switchboard Practice?"**

**THE CUTTER COMPANY,**
**19TH & HAMILTON STREETS,**
**PHILADELPHIA.**

6996

**MANUFACTURERS OF**

TRADE **G. I.** MARK

| ARC LAMPS D. C. | Bulletin No. |
|---|---|
| Long type "O" 110 V. Multiple | 171 |
| "L 11" " 100 to 125 V. " | 272 |
| "L 12" " 200 to 250 V. " | 173 |
| "L 5" " 5 to 7 Amp. Series | 175 |
| "L 3" " 200 to 600 V. Series | 174 |
| **ARC LAMPS A. C.** | |
| "L 6" type 60 to 133 Cycles Multiple. | 182 |
| "L " " Shuntwound Series | 288 |
| "L 8" " difftl. " " | 288 |
| Incandescent Lamps | 190 |
| Motors, Motor Generators | 164 |
| Fan Motors | 202 |
| Sewing Machine Transmitters, D. C. & A. C. | 165 |
| Etc., Etc. | |

| SWITCHES. | Bulletin No. |
|---|---|
| High Tension Oil | 153 |
| Slow Break (Knife) | 150 |
| Quick Break (Knife) | 150 |
| Flush Push Button | 154 |
| Automatic | 154 |
| Voltmeter and Ammeter | 155 |
| Circuit Breakers, U. L. and O. L. | 152 |
| Underground Apparatus | 191 |
| Flush Receptacles and Plugs | 154 |
| Water Tight Floor Outlet Boxes | 94 |
| Switch Boards | 150 |
| Panel Boards and Fuse Carriers | 51 |
| Rheostats, Starters and Regulators. | 240 |
| Wright Discount Meters | 193 |
| Etc., Etc. | |

**Write for Bulletins and Prices:**

# GENERAL INCANDESCENT ARC LIGHT CO.

FACTORY AND GENERAL OFFICES:

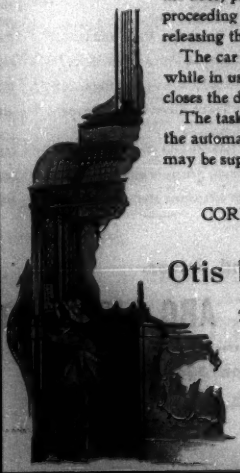
572-578 FIRST AVENUE, Cor. 33d STREET,

NEW YORK.

4294

# The Otis Automatic Electric Elevator

answers the pressure of a button by coming to the floor signaled from and stopping itself there. Until it has come to rest opposite the door, same is locked, but now you find it released, and step in, closing the door. All doors are locked except the one opposite which the car is at rest and the car can move neither up nor down while any door is open A row of buttons, designated, one for each landing, is in the car and after entering and closing the door, pressing one of these results in the car proceeding to and stopping at that floor and releasing the door for exit.



The car will respond to no interfering call while in use until the occupant passes out and closes the door.

The task of adapting houses already built to the automatic elevator is not as formidable as may be supposed.

CORRESPONDENCE INVITED

## Otis Elevator Company

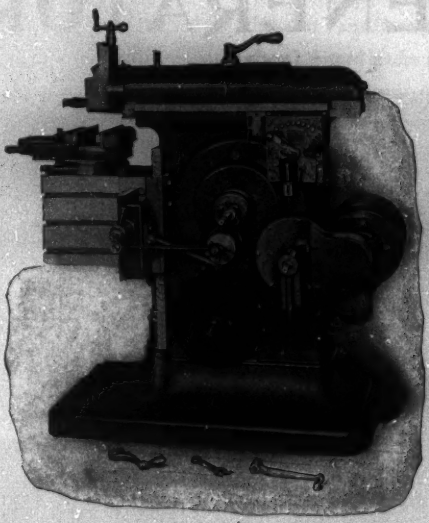
71 Broadway, New York

*Branch offices throughout the country*

# Storey Variable Speed Motors

Are thoroughly well designed and carefully constructed.

300% Speed Change



Without Using Rheostats.

May be connected to any ordinary lighting or power circuit.

## STOREY MOTOR & ELECTRIC CO.

HARRISON. (Newark.) NEW JERSEY

Sales Office; 135 Broadway, New York.

# BULLOCK

ALTERNATING CURRENT

# GENERATORS

ANY SIZE DESIRED

1 000 K. W. Revolving Field Bullock Generator and Type "H-I" Exciter.
Plant of M. P. Davis, Shieks Island, Canada.

**Our Alternating Current Generators are of the revolving field type, and are built for direct connection to engines or water wheels, or for belt connection. Superior regulation. High efficiency. Pleasing outline.**

WRITE FOR BULLETINS

**BULLOCK ELECTRIC MFG. CO.,**

**Cincinnati, U. S. A.**

# Western Electric Company

W. E. Motor Driven Exhaust Fans have peripheral shaped blades producing a maximum wind output. Supporting frame being cast in one piece ensures strength and rigidity.

Bulletin No. 3020 sent on request

Chicago—St. Louis—Denver—Philadelphia—New York

# Crocker-Wheeler Company

AMPERE, N. J.

Manufacturers and Engineers

for economical methods of electric drive.

# ELECTRICAL TESTING

We are now prepared to undertake
Electrical testing of all kinds.
Electrical and Photometrical Standardization.
Tests of Lamps, Instruments, Materials and Supplies.
Secondary Standards of Candle-power furnished.

LAMP TESTING BUREAU,

Telephone 3388 Franklin.

No. 14 Jay Street, New York.

# LONG LIFE

is usually the result of a strong, hearty constitution.

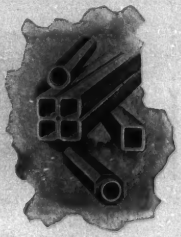
TOERRING
LONG LIFE ARC LAMPS

have an especially strong constitution, enabling them to successfully withstand such troubles as arc lamps are heir to. They require no dosing because they are constructed on the principle that an ounce of prevention is better than a pound of cure.

C. J. TOERRING CO.,
19th St. & Allegheny Ave, Philadelphia.
New York Office: 39 Cortlandt St.

# VITRIFIED
# GLAZED CLAY
# CONDUITS

MULTIPLE-DUCT-SINGLE



C. J. FIELD

29 Broadway, New York

Sole Agent for Factories

Large Factories
Moderate Prices Best Conduits

# Bishop Wires and Cables

4290

Meeting the most trying conditions a specialty.
All kinds of FLEXIBLE CABLES. For Controlling, for Electric Lights, and for Annunciators in ELEVATORS
Also for Theatre and other trying work

## BISHOP GUTTA-PERCHA COMPANY

422-426 EAST 25TH ST., NEW YORK

---

The

7161

# American Bell Telephone Company,

125 Milk Street, Boston, Mass.

---

U INDICATING FUSES D.

S &

E W.

4293

TYPE C. FUSE AFTER BLOWING.

See the "BULL'S EYE."

PIONEERS OF THE ENCLOSED FUSE INDUSTRY.

D. & W. FUSE CO., Providence, R. I.

Again
and again,
for many years,
under all conditions,
by countless users, the

**Remington Typewriter**

has been tried and tested, and its superior merits proved.

Remington Typewriter Company
New York

**Report of Committee on the Standardization of**

**ELECTRIC GENERATORS, MOTORS AND TRANSFORMERS.**

This report, which has been in preparation since January, 1898, has now been published for general distribution. It is receiving the endorsement of leading manufacturers and engineers.

**Single Copies Postpaid, 10c. each.**

**In quantities of 10 or more, 5c. each.**

Address

**R. W. POPE, Secretary,**

**95 Liberty St., New York City.**

## COPPER WIRE TABLE.

This table gives the WEIGHTS, LENGTHS and RESISTANCES of cool, warm, and hot wires of

***MATTHIESSEN'S STANDARD CONDUCTIVITY,***

for both Brown and Sharpe (A. W. G.) and Birmingham Wire Gauges (B. W. G.)

It was prepared by the Institute Committee on Units and Standards, personally revised by the individual members of the Committee, and issued with the October, 1893, number of the TRANSACTIONS, forming a part of Volume X.

Mailed separately, price 10 cents.

**Ralph W. Pope**, Secretary, 95 Liberty Street,
New York City.

EVERY ELECTRICAL ENGINEER

needs in his professional work

ELECTRICAL WORLD AND ENGINEER

whose pages give each week particulars of all that is being done in the science and industry.

SUBSCRIPTION RATES.

United States, Canada or Mexico, $3.00 per year. (Issued weekly.)
All foreign countries within the Postal Union, $6.00 per year.

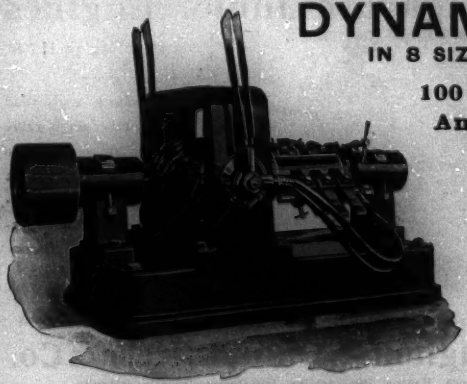
English coinage, 25 shillings.
German " 25 marks.
French " 31 francs.
Spanish " 31 francs.

International Money Orders for $6.00 (American) preferred.

Any electrical book published will be sent by mail, postage prepaid, to any address in the world on receipt of price. Write for catalogue.

Electrical World and Engineer,
114 Liberty Street, New York, U. S. A.

695



DYNAMOS
IN 8 SIZES.

100 to 2,500 Amperes.

5 to 6 Volts.

M. P.
& B. P.
Types.

675

Electroplating. Electrotyping.

CHAS. J. BOGUE, 213 Centre St., New York.

Cable address, "Machelect," New York.

# Westinghouse
## Integrating Wattmeters

Register
All the Energy
All the Time
No More---No Less

Accurate for years without cleaning or recalibration

Write for Folder 4003

**Westinghouse**
Electric & Mfg. Co.,
Pittsburg, Pa.

Sales Offices in all Large Cities

## Westinghouse Junior Engines
5 H. P. to 75 H. P.

Economy unequalled by any other single valve engine and on variable loads and light loads superior to the best accepted types of four-valve, simple, non-condensing engines.

Westinghouse Junior Engine Generating Set.

For particulars address

## Westinghouse, Church, Kerr & Co.
New York, Boston, Philadelphia, Pittsburg, Chicago, Detroit
**Engineers**

Also sell the product of

## The Westinghouse Machine Co.
PITTSBURG Designers and Builders of CHICAGO
Steam Engines, Gas Engines, Steam Turbines, Roney Mechanical Stokers

# GENERAL ELECTRIC COMPANY'S

## *TYPE "H" TRANSFORMERS*

### *CORE TYPE.*

In type "H" Transformers, where it would not be economical to limit the thickness of coils to one and one-half inches, ducts for the circulation of cooling oil are provided between the windings and the iron core.

Unequal expansion of transformer windings, which always causes weakening of the mechanical and electrical strength of the insulations can be avoided only when temperatures throughout the windings are maintained perfectly uniform.

It is evident that this uniform heating can exist only when all parts of the windings are at a uniformly short distance from the cooling oil.

*Type "H" Transformers* —even of the largest size— never have any part of the copper more than one and one-half inches from the cooling oil. Therefore *temperatures and expansions are uniform* in all parts—a result even more desirable than low average temperature.

---

GENERAL OFFICES:

SCHENECTADY, N. Y.

New York Office, 44 Broad Street. Sales Offices in all Large Cities.

# JOHN A. ROEBLING'S SONS CO

MANUFACTURERS OF

# HIGH TENSION CABLES

WITH

Paper and Rubber Insulation for any Voltage

# TELEPHONE CABLES

Weatherproof Wire

Magnet Wire

## IRON, STEEL AND COPPER WIRE

WIRE ROPES FOR ALL PURPOSES

MAIN OFFICE AND WORKS, TRENTON, N. J.

Branch Offices and Stores,

NEW YORK, CHICAGO, CLEVELAND, SAN FRANCISCO.